International Journal of Advanced Social Studies
ISSN: 3006-1776 (Print), 3006-1784 (Online)

Research Article

Impact of Adoption of Advanced Agricultural Technologies on Farmer's Income: Evidence from Central Punjab, Pakistan

Article History
Received: August 11, 2023
Revised: November 30, 2023
Accepted: December 15, 2023
Published: December 30, 2023

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Abstract

Technology has significantly enhanced farmers' lives, primarily by facilitating access to market information, thereby mitigating the exploitation of farmers. Over the past century, farming methods and techniques have undergone numerous advancements and considerable changes. The main objective of the current research was to estimate the effect of farmer's socioeconomic characteristics and advanced technological adoption on farmer's income. For this purpose, Sargodha District was selected, and data collection involved conducting a survey. A well-structured questionnaire was distributed among 200 farmers across 6 Tehsils in the district of Sargodha. The study utilized an econometric model of Ordinary Least Squares (OLS), opting for a linear function to minimize the sum of squares of differences among observed values. According to the results of the study, there is a positive relationship between the adoption of advanced technology and agricultural income. It underscores the pivotal role that governments and agricultural welfare organizations should play a key role in technological advancement in agriculture. Increasing education can enhance the technology adoption process, while a necessary sensitization campaign is essential to facilitate the transition from traditional techniques to advanced techniques.

Keywords: Advanced technologies, Agriculture, Income, Farmers, socio-economic characteristics.

Introduction

The primary objective of Pakistan's agriculture sector is to ensure sufficient food and nutrition for its people while also serving as a source of income and facilitating value-added production. However, the sector experienced a growth rate of only 0.85 percent, significantly below the targeted goal of 3.8% set at the beginning of the year. Several factors contributed to this underperformance, including limited access to water and a decline in fertilizer usage, resulting in a reduction in cultivated land (GOP, 2019). Despite these challenges, Pakistan's agriculture sector remains the second-largest in the country, contributing approximately 19.5% to the Gross Domestic Product (GDP) and playing a crucial role in employment generation. Indeed, it is the largest employer sector in Pakistan, with 42.5% of the labor force employed within it (GOP, 2017). The bulk of the population's livelihoods, directly or indirectly, rely on labor participation, making agriculture the largest sector of Pakistan's economy. However, its contribution to GDP has gradually declined over the past few decades. Nonetheless, there is still significant potential for this sector to enhance its contribution to the gross domestic product by increasing output through the adoption of advanced agricultural technologies (GOP, 2020). According to Lapple et al. (2016), agricultural innovation can be classified into two categories: technological and non-technological innovations. A policy option proposed by Arshadullah (2017) is for the government to provide financial support to poor farmers, enabling them to access advanced equipment and tools. Additionally, it was observed that early adopters of technology derived greater benefits compared to those who adopted later, emphasizing the importance of proficient utilization through evaluation processes (Imtiaz et al., 2015).

Farmers with less area of irrigation face so many hurdles regarding the adoption of advanced technologies these can be internal problems or external issues. That became the reason for the slower adoption of new technology. But now the problem is currently concerned with whether it will be worth using technology for the agriculture sector. This is also confirmed that with the growth of any country utilization of machines and technology is linked together. The peasant who does not use and avail the modern varieties found more treat in local as well as foreign markets in quality and yield differentials as well as concerning gap in prices. Due to a lack of knowledge in the adoption of advanced technology farmers according to specified crops farmers can be themselves capable of getting research funding and that's way grow orphan crops which leads to low productivity. For the welfare of poor farmers and the maintenance of agriculture in the era of a green revolution, there arises the need for agricultural advanced technology, which must be focused on the problem of administration and management limitations. The objective of the current study was to estimate the impact of different factors on the adoption of advanced technologies and the impact of adoption on farmer's income.

Agricultural production relies on various resources, with technology standing out as a significant component. Ingold (2002) highlights that the adoption of agricultural innovations significantly impacts farmers' welfare, agricultural productivity, and the economics of the food sector. Ingold (2002) distinguishes between technique and technology, noting that techniques pertain to the capabilities and skills of individual human subjects, while technology typically involves a body of objective knowledge with practical applications. The decision to adopt technology hinges on farmers' perceptions of its utility, and they often acquire technology through technology transfer mechanisms (Nkonya et al., 1980). Research laboratories and universities can be effective sources as 'generators' for transferring technology to clients such as farmers, as it is a general process of moving information and skills (Valera et al., 1987).

Thierfelder et al. (2015) further explored the reasons behind minimal adoption rates in rural areas, attributing it to the scarcity of resources. This underscores the importance of sufficient resources and standardized inputs. Additionally, they examine the impact of socioeconomic factors on the adoption of advanced agricultural technologies. Senyolo et al. (2018) highlight the significant challenge of inadequate and insufficient adoption of output-enhancing innovations, particularly in Pakistan. Therefore, it is imperative to identify this issue and address the barriers hindering the adoption of new technology. Similarly, Zhang and Wu (2018) argue that the ultimate decision to adopt any innovation hinges on the farmer's connection with market associations and input providers for sustainable agricultural practices. They emphasize the need for integration between these entities to ensure the sustainable use of land. Anjum et al. (2020) examined the impact of microfinance on the socioeconomic status of farmers in Dera Ismail Khan district. Javed and Zahra (2023) investigated how farmers' socioeconomic characteristics and technology adoption influence agriculture in Pakistan.

Methodology

Sampling and Data Collection

In the research methodology, Sargodha District was chosen as the study area for several reasons. It was deemed feasible and suitable for the nature of the research due to its active farming practices and renowned status for orange production, alongside the cultivation of crops like wheat, rice, sugarcane, and maize in Pakistan. To ensure accuracy and reliability, a well-structured and organized survey form comprising a combination of close-ended questions was designed for data collection. Data was collected using random sampling techniques from 200 farmers, which was considered convenient, particularly given the ongoing COVID-19 pandemic situation. A survey was conducted in Sargodha District to collect data, wherein a well-organized questionnaire was distributed among 200 farmers.

Empirical Methodology

In statistical methodology, the Ordinary Least Squares (OLS) technique was developed by Carl Friedrich Gauss in 1795, but it was formally published in 1805 by Adrian-Marie Legendre. OLS is commonly employed in linear regression analysis to estimate unknown parameters and is regarded as a form of linear least squares method. It functions by minimizing the sum of squares of differences within the dependent variable, as depicted in the model or given dataset, through the selection of parameters for independent variables in a linear function.

In relation to the regression line, the disparity between the scattered data points and this regression surface is viewed as the sum of squared distances, which needs to be minimized. This minimization is crucial as it enhances the model's accuracy in estimating the dataset geometrically. The outcomes of the estimators can be succinctly described using simplified formulas, particularly in the case of linear regression with a single predictor variable on the right side of the equation. OLS has demonstrated efficiency as an estimator when the error terms are serially uncorrelated and homoscedastic. It also ensures unbiasedness of the mean and minimizes variance in estimation. Moreover, OLS functions as a maximum likelihood estimator if the error terms are assumed to follow a normal distribution.

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These effects of advanced technology adoption are given below which were used as independent variables in the analysis.

$$AGI = \beta_0 + \beta_1 AGE + \beta_2 EDU + \beta_3 EXP + \beta_4 FMEM + \beta_5 FLAB + \beta_6 LAND + \beta_7 OI + \beta_8 \text{FMEM\_EN} + \beta_9 \text{MSTA} + \beta_{10} ADP + \beta_{11} \text{AGAS} + \beta_{12} \text{FSYS} + \beta_{13} \text{FEXPN} + \beta_{14} \text{TSTAT} + \mu \quad (1)$$

Variables

AGI=Income from agriculture per acre annually (Thousands)

AGE= Age of the farmer (Years)

EDU= Education of the farmer (Schooling years)

EXP= Experience of the farmer (Years)

FMEM=Family members (Numbers)

FMEM_ EN=Family members engaged in farming (Numbers)

AGAS=Agriculture assets (Thousands)

FSYS=Family system (Joint= 1 Single=0)

MSTA=Marital status (Married=1 Single=0)

FEXPN=Family Expense (Thousands)

TSTAT=Tanural status (owner=1 other=0)

FLAB=Family labor (Numbers)

LAND=Farm Size-Total number of hectares (Land) or land holding (Acres)

OI=Off Farm income (Thousands)

ADP=Adoption (adoption level)

Results and Discussion

The level of adoption of 1% farmers is 1 which shows that only 1% of farmers are adopting only 1 technology among six technologies. The level of adoption of 25.5% farmers is 2 which shows that 25.5% of farmers are adopting only 2 technologies from six technologies. The level of adoption of 23.5% farmers is 3 which shows that 23.5% of farmers are adopting only 3 technologies amongst six technologies. Only 7% of farmers are adopting all six technologies as shown in (Table 1).

Table 1. Level of adoption of advanced technologies.

Adoption	Frequency	Percent
1	2	1.0
2	51	25.5
3	47	23.5
4	58	29.0
5	28	14.0
6	14	7.0
7	0	0
8	0	0

Source: Own computation.

Relation of Adoption with Other Socio-economic Variables

The level of adoption is maximum in 30 to 45 years of age of farmers as compared to less than thirty and more than forty-five. Farmers adopting 1 agriculture technology are 2 in less than 30 years while in 30 to 45 and more years, no one is adopting 1 technology. Farmers adopting 2 agriculture technologies are 29 in less than 30 years age while in 30 to 45, 10 farmers are adopting 2 technologies, and farmers who are more than 45 years old adopting 2 technologies are 12 in numbers.

Table 2. Level of adoption associated with age.

Adoption	Less than 30 years	31 to 45 years	More than 45 years
1	2	0	0
2	29	10	12
3	12	22	13
4	22	30	6
5	5	17	6
6	4	6	4
7	0	0	0
8	0	0	0

Farmers adopting 3 agriculture technologies are 12 in less than 30 years while in 30 to 45, 22 farmers are adopting 3 technologies, and farmers who are more than 45 years adopting 3 technologies are 13 in numbers. The data shown in Table 2 clearly represent that a major number of farmers in all age ranges are adopting 4 technologies, on the other hand, fewer farmers adopt 1 technology.

Table 3. Level of adoption associated with income from agriculture.

Adoption	Less than 50,000	51,000 to 100,000	More than 100,000
1	0	2	0
2	38	9	4
3	29	12	6
4	34	22	2
5	6	16	6
6	3	4	7
7	0	0	0
8	0	0	0

The adoption is utmost of more than 100,000 income from agriculture of farmers as compared to all other income brackets. Farmers adopting 1 agriculture technology are 2 in 100,000 income from agriculture of farmers and more than that no one is adopting 1 technology as well as under 50,000 income. Farmers adopting 2 agriculture technologies are 38 of less than 50,000 income while in the 50,000 to 100,000 range of income, 9 farmers are adopting 2 technologies, and farmers who are more than 100,000 income adopting 2 technologies are 4 in numbers. Farmers adopting 4 agriculture technologies are 34 in less than 50,000 income while in 50,000 to 100,000, 22 farmers are adopting 4 technologies, and farmers who are earning more than 100,000 adopting 4 technologies are only 2 in numbers. The data shown in Table 3 clearly represent that the major number of farmers lies in Less than 50,000 and 50,000 to 100,000 income brackets are adopting 4 technologies, on the other hand, farmers earning more than 100,000 adopting 6 technologies are 7 in numbers. No one is adopting all 7 and 8 technologies.

Table 4. Level of adoption associated with land holding.

Adoption	Less than 10 acres	11 to 20 acres	More than 20 acres
1	2	0	0
2	43	5	3
3	37	3	7
4	39	16	3
5	13	11	4
6	3	6	5
7	0	0	0
8	0	0	0

Landholding and level of adoption present in (Table 4) that how many acre landholders adopt all technologies. The level of adoption of all six technologies is maximum in 10 to 20 acres of land of farmers as compared to less than ten and more than twenty. Farmers adopting 1 agriculture technology are 2 possess less than 10 acres while in 10 to 20 acres and more than 20 acres no one is adopting 1 technology. Farmers adopting 2 agriculture technologies are 43 in less than 10 acres while in 10 to 20 acres, 5 farmers are adopting 2 technologies, and farmers who are more than 20 acres adopting 2 technologies are only 3 in numbers. Farmers adopting 4 agriculture technologies are 39 in less than 10 acres while in 10 to 20 acres, 16 farmers are adopting 4 technologies, and farmers who are more than 20 years adopting 4 technologies are just 3 in number. The data shown in Table 4 clearly represent that the major number of farmers in all ranges of 10 to 20 acres are adopting six technologies, on the other hand, less than ten-acre landholder farmers are adopting 4 technologies in major numbers (39) while more than 20 acres landholder adopting 3 technologies frequently.

Table 5. Level of adoption associated with education.

Adoption	Under Matric	Matric	FA	BA	MA
1	2	0	0	0	0
2	36	11	2	2	0
3	23	10	7	3	4
4	17	5	15	18	3
5	2	4	8	5	9
6	4	0	3	2	5
7	0	0	0	0	0
8	0	0	0	0	0

The level of adoption is maximum in highly qualified (masters) farmers as compared below master shown in Table 5. Farmers adopting 1 agriculture technology are 2 under matric, while from matric to masters no one is adopting 1 technology. Farmers adopting 2 agriculture technologies are 36 under matric, 11 are matric, while in FA and BA 2 farmers adopting 2 technologies, In case of MA, no one is adopting 2 technology. Farmers adopting 3 agriculture technologies are 23 are under matric, 10 are matric, 7 are FA, 3 are BA and 4 are masters. The data shown in Table 5 clearly represent that the major number of farmers adopting six technologies are MA while a major number of farmers (36) adopting 2 technologies are under matric.

Table 6. Level of adoption associated with experience.

Adoption	Less (<) than 5 years	6 - 10 years	11 - 15 years	More (>) than 15 years
1	0	0	2	0
2	6	15	11	19
3	2	3	16	26
4	3	19	8	28
5	0	5	2	21
6	2	2	0	10
7	0	0	0	0
8	0	0	0	0

The level of adoption is maximum in farmers having more than 15 years of experience as compared to less than 15 years. Farmers adopting 1 agriculture technology are 2 in 10 to 15 years more than that or less than 10 are not adopting 1 agriculture technology. Farmers adopting 2 agriculture technologies are 6 with less than 5 years' experience, 15 farmers are adopting 2 technologies with 5 to 10 years' experience, 11 farmers adopting 2 technologies with 10 to 15 years' experience, and 19 farmers who have more than 15 years of experience adopting 2 technologies. Farmers adopting 5 agriculture technologies are 21 with more than 15 years while 2 farmers have 10 to 15 years of experience, 5 farmers are adopting 5 technologies have 10 to 15 years of experience, and farmers who have less than 5 years of experience are not adopting 5 technologies. The data shown in (Table 6) undoubtedly represent that a major number of farmers have more than 15 years of experience adopting all technologies, which means with more years of experience farmers adopt more technologies.

Impact of Adoption of Advanced Technologies on Farmer's Income

For the target of drawing inferences about the adoption of agriculture technology and its impact on farmer's income, the collected sample data were evaluated.

Table 7. Descriptive statistics.

(Variables)	(Mean)	(Minimum)	(Maximum)	(Std. Deviation)
Income From Agriculture	59.8300	20.00	120.00	28.24749
Adoption	3.5050	1.00	6.00	1.23597
Land Holding	11.0450	5.00	50.00	8.86997
Family Member Engaged in faming	2.4350	1.00	8.00	1.54847
Marital Status	.7600	.00	1.00	.42815
Family System	.7550	.00	1.00	.43117
Off Farm Income	23.8750	.00	63.00	18.37081
Age	36.9900	20.00	80.00	11.84913
Education	10.0250	4.00	16.00	3.61799
Experience	15.7800	2.00	50.00	9.78521
Family Member	6.8550	1.00	25.00	3.21491
Farm Labor	2.5600	.00	35.00	3.60853
Family expenses	41.9700	10.00	200.00	22.37324
Agriculture Asset	3.7597E2	.00	2000.00	381.57920
Tenural Status	.6400	.00	1.00	.48120

The data indicates (Table 7) that, on average, farmers have an income of 59.83 thousand rupees per month. The income ranges from a minimum of 20,000 to a maximum of 120,000 per month, with a standard deviation of 28.248. The average adoption level of agricultural techniques is 3.5050, ranging from a minimum of 1.00 to a maximum of 6.00. Regarding marital status, on average, 0.7600 farmers are married/not single, with a standard deviation of 0.42815. Similarly, the average number of farmers belonging to a joint family system is 0.755, with a standard deviation of 0.43117. The mean value of off-farm income is 23.8750 rupees per month, ranging from zero to 63 thousand, with a standard deviation of 18.37081. The average age of farmers is 36.99 years, ranging from 20 to 80 years, with a standard deviation of 11.84913. Farmers typically have an average of 10.02 years of education, ranging from 4 to 16 years, and an average of 15.78 years of farming experience, ranging from 2 to 50 years, with a standard deviation of 9.78521. The mean number of farm laborers is 2.56, ranging from 0 to 35, with a standard deviation of 3.6085.

Table 8. Multicollinearity statistics.

Variables	Tolerance	VIF
Land Holding	.656	1.525
Family Member (in farming)	.548	1.826
Marital Status	.690	1.450
Family System	.693	1.443
Off Farm Income	.646	1.549
Age	.469	2.131
Education	.581	1.722
Experience	.492	2.032
Family Member	.513	1.949
Labor on Farm	.851	1.176
Expenses (Family)	.598	1.672
Asset (Agriculture)	.819	1.221
Tenural Status	.671	1.491
Adoption	.466	2.147

The values of VIF of all variables are below 10 which means that there is no existence of multicollinearity in analyzed data (Table 8).

The family system demonstrates a positive and significant effect on income from agriculture. A one-unit increase in the family system is associated with an increase in agriculture income by 9.361 thousand. Similarly, off-farm income exhibits a positive and significant influence on income from agriculture, with every one-thousand-rupee increase in off-farm income leading to a 0.254 thousand increase in agriculture income. Conversely, the level of education shows a negative and significant impact on income from agriculture. For each additional schooling year, there is a decrease in agriculture income by 0.918 thousand.

There is a significant effect of family members on income from agriculture. One unit increase in the number of family members will increase the income from agriculture by 2.186 thousand so their relation is positive. There is a negative and significant impact of farm labor on income from agriculture. A rise in farm labor by one unit will diminish/decrease the income from agriculture by 0.022 thousand. The impact of family expenses is positive and significant. One thousand increases in family expenses will increase the income from agriculture by 0.144 thousand. One unit increase in tanural status will increase the income from agriculture by 11.506 thousand. The impact of tanural status is positive and significant. One unit increase in adoption of advanced agriculture technologies will increase the Income from agriculture by 8.766 thousand. The impact of the adoption of advanced agriculture technologies is positive and significant. These results were spotted by Hailu et al. (2014). prior hypothesis stating the positive impact of the adoption of agricultural technology on farm income.

Table 9. Impact of adoption of advanced technologies on farmer's income.

Variables	Coefficients	Std. Error	t	Sig
Land Holding	-.137	.246	-.558	.578
Family Member Engaged in Farming	-1.906	1.542	-1.23	.218
Marital Status	3.050	4.967	.614	.540
Family System	9.361	4.922	1.902	.059
Off Farm Income	.254	.120	2.124	.035
Age	.000	.218	-.003	.997
Education	-.918	.641	-1.43	.154
Experience	.025	.257	.099	.921
Family Member	2.186	.767	2.850	.005
Farm Labor	-.022	.531	-.041	.968
Family Expenses	.144	.102	1.411	.160
Agriculture Asset	-.003	.005	-.500	.618
Tenural Status	11.506	4.482	2.567	.011
Adoption	8.766	2.094	4.186	.000
R2	.277			
Adjusted R2	.222			
F value	5.051			

The impact of landholding size on agriculture income is negative but insignificant. A one-acre increase in landholding size is associated with a decrease in agriculture income by 0.137 thousand, although this relationship is not statistically significant. Similarly, the number of family members engaged in farming has a negative and insignificant impact on agricultural income. An increase of one unit in family members engaged in farming is associated with a decrease in agriculture income by 1.906 thousand, but this effect is not statistically significant. Marital status shows a positive and insignificant impact on agriculture income. A one-unit increase in marital status is associated with an increase in agriculture income by 3.050 thousand, though this relationship lacks statistical significance. Experience exhibits a positive and insignificant impact on agriculture income. A one-year increase in experience leads to a 0.025 thousand increase in agriculture income, yet this effect is not statistically significant.

Agriculture assets demonstrate a negative and insignificant impact on agriculture income. A one-thousand-rupee increase in agriculture assets is associated with a decrease in agriculture income by 0.003 thousand, although this relationship lacks statistical significance. Based on the data presented in Table 9, the coefficient of determination (R-squared) is 0.27, indicating that all the explanatory variables collectively account for 53% of the variation in the dependent variable, which is income from agriculture. Clearly understandable results were also generated through it which is that 73% is unexplained variation in the dependent model which does not occur due to explanatory variables in the model. The adjusted R square represents that 22% variation adjusted with degree of freedom occurred through explanatory variable as well as F- value 5.051 ($p < 0.05$) narrates that is significant and appropriateness of model in Table 9.

Conclusions

The findings from this analysis reveal various factors that either promote or hinder the adoption of advanced technology among farmers, subsequently impacting their income. We have observed a positive correlation between farmers' socio-economic characteristics and their adoption of advanced technology. These characteristics encompass landholding, the involvement of family members in farming, family structure, education level, and farming experience. Regarding the relationship between adoption levels and agricultural income, there is a positive correlation between the adoption of advanced technology and income from agriculture. Conversely, there is a negative association with all other socio-economic variables. The primary obstacle to the adoption of advanced technology and the subsequent stagnation in agricultural income is often attributed to a lack of knowledge. To improve farming strategies and overcome barriers to technology adoption, farmers must actively seek information and knowledge about modern agricultural techniques.

References

Anjum, M. N., Abdur, R., Khan, M. N., Raheel, S., Mohammad, F., & Iqbal, J. (2020). Impact of microfinance on the socioeconomic status of farmers in district Dera Ismail Khan. Sarhad Journal of Agriculture, 36(3), 851-860.

Arshadullah, J. (2017). Cointegration between Modern Agricultural Technology and Farm Productivity in Pakistan. European Academic Research, 8, 4216-4234.

GOP. (2017). Economic Survey of Pakistan. Economic Advisor's Wing, Finance Division, Ministry of Finance.

GOP. (2019). Economic Survey of Pakistan. Economic Advisor's Wing, Finance Division, Ministry of Finance.

GOP. (2020). Economic Survey of Pakistan. Economic Advisor's Wing, Finance Division, Ministry of Finance.

Hailu, B. K., Abrha, B. K., & Weldegiorgis, K. A. (2014). Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. International Journal of Food and Agricultural Economics (IJFAEC), 2(1128-2016-92058), 91-106.

Imtiaz, S., Zeeshan, M., & Tahir, S. (2015). Advanced Technology and Agriculture Production: A Study of Adoption Technology, Journal of Social Sciences, 1(7), 232-236.

Ingold, T. (2002). The Perception of the Environment, Essays in Livelihood, Dwelling and Skill (Review). Technology and Cultural Technology, 43(2), 401-402.

Javed, I., & Zahra, K. (2023). Impact of Farmer's Socioeconomic Characteristics and Technology Adoption on Agriculture Income: Evidence from Central Punjab, Pakistan. International Journal of Advanced Social Studies, 3(1), 42-51.

Lapple, D., Renwick, A., Cullinan, J., & Thorne, F. (2016). What Drives Innovation in the Agricultural Sector? A Spatial Analysis of Knowledge Spillovers. Land Use Policy, 56, 238-250.

Nkonya, E., T. Schroeder, and Norman, D. (1980). Factors Affecting Adoption of Improved Maize Seed and Fertilizer in Northern Tanzania. Journal of Agricultural Economics. 48(1), 1-12.

Senyolo, P. et al, (2018). How the Characteristics of Innovations Impact Their Adoption: An Exploration of Climate-Smart Agricultural Innovations in South Africa. Journal of Cleaner Production, 172, 3825-3840.

Thierfelder, C, Bunderson, Trent, w, & Mupangwa, W. (2015). Evidence and Lessons Learned from Long-Term On-Farm Research on Conservation Agriculture Systems in Communities in Malawi and Zimbabwe. Environments, 2(3), 317-337.

Valera, J. B., Martinez, V. A., & Plopino, R. F. (1987). An Introduction to Extension Delivery Systems. Manila: Island Pub. House.

Zhang, L., & Wu, B. (2018), Farmer Innovation System and Government Intervention: An Empirical Study of Straw Utilisation Technology Development and Diffusion in China. Journal of Cleaner Production, (188), 698-707.