# Using Agricultural Production Functions to Analyse Land Tenure Reforms

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**Abstract**

Agricultural land policy changes have important implications for an economy. Their effect on agricultural productivity is of great interest. This chapter aims to provide the necessary knowledge and skills to carry out an ex post analysis employing econometric techniques to understand the impact of agricultural land policies (pertaining to tenure rights and land sizes) on agricultural productivity. Specifically, upon completing the chapter, the reader should be able to evaluate the impact of changing land plot sizes on agricultural productivity and, by using a simple dummy variable method, the effect of ownership on agricultural productivity employing the Excel spreadsheet or STATA software. The chapter concludes with an exercise to practice the methods explained in the chapter with a data set provided.

**Keywords**

Land policies · Tenure rights · Land size · Productivity · Ex post analysis

## 15.1 Introduction

Land is an important resource for both national and rural development. It is an important source of wealth in rural areas as, observations show, people with land endowments enjoy better living standards compared to those who are landless. It is the most vital input for agricultural production, and land quality influences yields and farm incomes. Given its importance in agriculture, land is central to food security, foreign exchange earnings, and rural employment in a country. Also,

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agricultural land is a highly politically sensitive subject owing to its centrality in rural livelihoods and the presence of large rural voter bases.

Agricultural land is of great interest to policymakers. Governments are required to take decisions with respect to land allocation, land use, land rights, and land transfer in order to achieve certain national goals as needs dictate. Hence, historically, land policies are one of the oldest public policies in any country.

Changes in government policies alter people's behaviour. Some behavioural changes are intended and others, unintended. Some are favourable; some, unfavourable. Since land is connected to all sectors, the outcome of a change in land policy might not be directly seen. A proposed change in land policy (in any public policy for that matter) may be evaluated before implementation (ex ante) and/or after implementation (ex post). Policies are analysed before implementation to quantify the likely impacts, as well as to understand the direction in which important variables could change upon the implementation of the policy. Policies may be withdrawn before implementation if analysis shows unfavourable outcomes. Moreover, a policy may be evaluated upon implementation to assess the magnitude and direction of the impact on important variables and, if necessary, amended accordingly. Therefore, policy analysis is as important as the policy itself. Agricultural land policies require rigorous analyses for the political, social, and economic advancement of a country.

## 15.2 The Context

### 15.2.1 Intentions of the Policy and Global Context

In ancient times, when land was abundant, there was no need for land policies. Later, as land increasingly became a scarce resource, decisions had to be taken on who has what rights to land and how best to use it productively (because the latter required high investments); i.e., property rights became a concern. Historically, the ruler or the governing body was vested with the ownership of land, which was distributed among the public for different purposes. In the feudal system, rent was collected by the ruler for occupying and using land. Commoners neither owned the land nor possessed the authority to engage in land transactions. In most places, the user rights to the land were transferred to the next generation mostly for the same use. This led to commoners rising in rebellion against the unequitable distribution of land, which was the basis of their livelihood. As a result, early land policies took account of issues of equity in the distribution of land. Property rights to land thus distributed were also defined to avoid confusion and conflict.

It is believed that having ownership rights to land increases efficiency. Property rights to land need to have a time horizon long enough to provide incentives for investment and be defined in a way that makes them easy to observe, enforce, and exchange. They need to be administered and enforced by institutions that have both legal backing and social legitimacy and are accessible by and accountable to the holders of property rights. Even if property rights to land are assigned to a group, the rights and duties of individuals within this group, and the way in which they will be enforced and can be modified, have to be clear. Finally, as the precision with which property rights will be defined will generally increase in line with rising resource values, the institutions administering property rights need to be flexible enough to evolve in response to changing requirements.

Historically, property rights to land were social conventions that regulated the distribution of the benefits that accrue from specific uses of a certain piece of land. Public interventions in terms of policies in this regard were required due to several reasons. First, unless property rights are defined and enforced by society, households and entrepreneurs will be forced to spend resources to defend their claims to property, for example through guards, fences, etc. This not only is socially wasteful but also disadvantages the poor, who will be the least able to afford such expenditures, and, in the extreme, leads to a chaotic situation. Second, the high fixed cost of the institutional infrastructure needed to establish and maintain land rights favours public provision, or at least regulation. Finally, the benefits of being able to exchange land rights at low cost, which are, for example, the basis for the use of land as collateral in credit markets, will be realised only in cases where such rights are standardised and can be easily and independently verified, e.g. through a publicly accredited registry of deeds or title that is guaranteed by the state (Christensen et al. 1973).

In any country, there are land policies that deal with the distribution of land to the public, acquisition of land from the public, and definitions of property rights, land uses, and development. Most countries experienced land reforms as a crucial milestone in their development path. For instance, post-war Japan undertook a land reform that is very much applauded across the world as a successful move. There, the government introduced a permissible limit to the extent of land that individuals could own to achieve a more equitable distribution of land among people. Landlords who owned more than the permitted amount were required to sell the excess land at a fixed price to the government, which then sold it at the same price, giving first preference to any tenant who had been farming the land. Japan's land reform succeeded for two reasons. The first is that the then ruling authority had the power to impose and enforce a law that hurt the interests of a very powerful class of people, wealthy landlords, in order to bring about social and economic change. The second reason is more complex. When the land reform law was passed in October 1946, it provided reasonable compensation to the landlords who had to sell their land to the government.

Another well-known example is China. Land reform has characterised rural China since the founding of the People's Republic in 1949. Shaping its farmland policy on the Soviet model, China established collective ownership and unified collective operation. During the reform process, individual farmers were compelled to join collectives. Collectivisation finally developed an institution called the People's Commune. This policy is criticised for its centrally controlled property rights and misapplied egalitarian principle of distribution; in effect, communes destroyed farmers' operational freedom and their enthusiasm for production (Chen and Davis 1998).

### 15.2.2 Milestones of the Policy Implemented in Sri Lanka

In Sri Lanka, land policy documents date back to the colonial era. The first land policy implemented was the Crown Land Ordinance in 1840, through which the colonial government appropriated private lands for the expansion of the plantation sector. All land for which the traditional users failed to provide deeds was taken under the Crown.

Since then, several land policies have been implemented to achieve various political and socio-economic objectives. Table 15.1 summarises the major policies. A policy is never perfect in its original form. Oftentimes, the original policy will be amended several times to iron out weaknesses. If there are drastic changes to an existing policy, its policy is repealed and a new policy issued in its place.

## 15.3 An Application

### 15.3.1 Selection of a Tool to Analyse the Effects of Agricultural Land Policies

There are several analytical tools available for empirical policy analysis. They may be categorised broadly as experimental methods and non-experimental methods. Randomised control trials (RCTs), field experiments, lab experiments, and discrete choice experiments are experimental methods available for policy analysis. Qualitative methods, simulations (partial/general equilibrium models and mathematical programming tools), and econometric methods are non-experimental methods available. The selection of an appropriate tool is dependent on several factors: the nature of the policy, the context (i.e. whether it requires an ex ante analysis or ex post analysis), the trade-off between internal and external validity, the type of data available, and the cost of the method (Colen et al. 2016).

Simulation models are commonly used in ex ante evaluations. Econometric analysis refers mostly to ex post evaluations and includes regression analysis and quasi-experimental approaches. Quasi-experiments are sophisticated econometric methods in which assignment to conditions (treatment versus no treatment or comparison) is via self-selection (participants choose treatment for themselves), by the researcher, or both of these routes by artificially constructing or mimicking the counterfactual (Shadish et al. 2002). Quasi-experiments include the following empirical strategies: instrumental variable estimations, regression discontinuity designs, difference-in-difference matching, and propensity score matching.

Some experimental and non-experimental methods are used complementarily. For instance, experimental methods and simulation methods are used together for ex ante analysis, whereas econometric analyses using observational data and RCTs are used together in ex post policy analysis.

This chapter will focus on the use of regression analysis to assess the effects of land policies.

**Table 15.1** Major land policies implemented in Sri Lanka

| Ordinances, acts and laws related to land ordinance/act/law | Year | Summary |
|---|---|---|
| Crown Lands (Encroachments) Ordinance No. 12 | 1840 | • Acquired around 90 per cent of existing lands in the country and converted them to Crown properties<br>• These lands were later sold to Europeans to start plantation agriculture, a land use unfamiliar to the native people |
| Waste Lands Ordinance No. 1 | 1897 | • Prevented encroachment of Crown wastelands by the peasants |
| Land Development Ordinance No. 19 | 1935 | • Set the course for the future development of lands in Sri Lanka<br>• Led to rapid land settlements; starting from the mid-1930s, continued up to the implementation of the Accelerated Mahaweli Development project in the mid-1980s |
| Paddy Lands Act, No. 1 | 1953 and 1958 | • Two major tenure reforms of Sri Lanka enacted to ensure tenure security and to regulate the rent paid by tenants to the landlords with the objective of improving land productivity through increasing the tenure security<br>• Led to a detrimental, rather than beneficial, landlord-tenure relationship and finally resulted in the eviction of a large number of tenants by the landlords |
| Land Reform Law, No.1<br>Land Reform (Amendment) Law, No. 39 | 1972<br>1975 | • Imposed an ownership ceiling of 25 acres of paddy lands or 50 acres of highlands or both together with a maximum of 50 acres<br>• Land ceiling was not effectively enforced<br>• Provision of small parcels of land to a large number of landless farmers led to increasing agricultural production over the years |
| Agrarian Services Act, No. 58 | 1979 | • To secure tenure rights of tenant cultivators of paddy and improve the productivity of those lands<br>• Considered as a more realistic approach to resolve the problems in the paddy sector |
| Agrarian Development Act, No. 46 | 2000 | • Identified the necessity of having a national policy to safeguard tenure rights<br>• Imposed restrictions on the conversion of agricultural land to non-agricultural purposes |
| Land Grants (Special Provisions) Act, No. 43 | 1979 | • Land under the purview of the Land Commissioner's Department was alienated for various purposes to the private sector |
| Registration of Title Act, No. 21 | 1998 | • To provide freehold titles to land parcels in order to promote the efficient functioning of land markets and resource utilization |

#### 15.3.1.1 Theoretical and Empirical Model

Production involves converting inputs to (an) output(s). Producers of agricultural commodities seek to maximise farm profits or, at least, maximise revenue subject to resource constraints, such as land, labour, and farm machinery. In any production process, the output depends on the factors used and the production technology in which they are combined. These input-output relationships, which can be expressed in a production function, provide the foundation for economic theory from a production perspective. A production function relates the physical output of a production process to the physical inputs or factors of production; it is a mathematical relationship that relates the maximum amount of output that can be obtained from a given number of inputs. There are many objectives of using production functions in empirical research: to derive the physical relationships of inputs and outputs, to derive marginal productivities of inputs, to assess the resource-use efficiency of decision-making units (e.g. technical and economic efficiency), to estimate technical/technological changes of a production process over time, and to test economic theories (e.g. diminishing marginal returns). Due to their appealing properties, production functions are used in a wide array of areas (Beattie and Taylor 1993).

The concept of duality in production theory (McFadden 1978) brought a breakthrough in the empirical application of production theories. Duality (or dual concept) means that all of the information needed to obtain the corresponding cost function is contained in the production function and, conversely, the cost function contains all of the information needed to derive the underlying production function. Consequently, according to the dual concept, any constrained maximisation problem can be converted into a corresponding constrained minimisation problem and vice versa. The use of inputs becomes the function to be minimised; the revenue function becomes the constraint. Since cost/price data are more easily available than quantity data, the estimation of the parameters of the production function indirectly from the profit/cost function data became increasingly popular (Beattie and Taylor 1993).

The application of the theory of the firm in agricultural commodities involves production functions, profit or cost functions, derived input demand functions, and output supply functions.

The farmer faces an allocation problem. She/he seeks to allocate resources such that profits are maximised and eventually her/his utility is maximised. Profit is the difference between the revenues obtained from what is sold (total value product) and the costs incurred (total factor cost) in producing the goods. From an input perspective, total profit is explained as the difference between the total value product (TVP) and the total factor cost (TFC). A farmer, under perfectly competitive conditions, receives constant output price ($p^*$), TVP $= p^*y$. Hence, profit becomes

$$\pi = p^*y - \mathrm{TFC} \tag{15.1}$$

Output $y$ is determined by the production technology, i.e. how inputs are combined and the quantities of inputs used:

$$y = f(x_1, \ldots, x_n | x_{n+1}, \ldots, x_m) \tag{15.2}$$

where $y$ is the output, $x_1, \ldots, x_n$ are the variable inputs, and $x_{n+1}, \ldots, x_m$ are the fixed inputs. In producing a crop, fertiliser, agrochemicals, and labour are some examples of variable inputs; land is an example of a fixed input. Quantities of variable inputs can be changed in a cultivation season, but fixed inputs cannot be changed.

Empirical estimation of the production relationships involves the selection of a functional form that best describes the relationship between the variables. The most common functional specification is the Cobb-Douglas (C-D) type.

$$y = x_1^{\beta 1} x_2^{\beta 2} \tag{15.3}$$

The common use of the C-D type specification is attributed to several characteristics of the C-D type. Most of all, there is the computational ease. Input elasticities can easily be obtained by the log-log specification of the C-D production function, where the input coefficients ($\beta_s$) are the input elasticities. The log-log specification of the C-D production function is as follows:

$$\log\ y = \beta_1 \log\ x_1 + \beta_2\ \log\ x_2 \tag{15.4}$$

However, the C-D type functional specification has a few weaknesses, which limit its ability to closely relate to the true functional form of the technical relationship of interest. Its inherent assumption of constant elasticity of substitution is one limitation of its empirical application. Elasticity of substitution is defined as the percentage change in the input ratio divided by the percentage change in the marginal rate of substitution. Due to these limitations, more flexible functional forms, such as constant elasticity of substitution (CES) production functions and transcendental logarithmic (translog)-type specification, have been used.

Specifically, the translog production function[1] introduced by Christensen et al. (1973) became popular due to its many advantages over the C-D or CES specifications. First, it does not assume rigid premises, such as smooth substitution between factors or perfect competition in factor markets (Klacek et al. 2007). Second, it permits non-linear relationships between the output and the factors. In addition, due to its properties, the translog production function can be used for the second-order approximation of a linear-homogenous production, the estimation of Allen elasticities, the estimation of production frontier, or the estimation of the total factor productivity dynamics (Pavelescu 2011). The general form of the translog production function for $i$ inputs is given below:

[1]The first form of a translog production function involved the approximation of a CES production function with a second-order Taylor series when the elasticity of substitution is very close to one.

$$lny = ln\alpha + \sum_{i=1}^{n} \beta_i \, ln \, x_i + \left(\frac{1}{2}\right) \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \, ln \, x_i \, ln \, x_j \quad (15.5)$$

The estimation of the production function for an annual crop is different from doing so for a perennial crop due to several reasons. One is incorporating capital expenditure on perennial crops. A grown perennial crop is capital accumulated over a period of time. Production functions are defined for a short period of time, usually a year. It is necessary to obtain the annual service flow from machinery cost when estimating production functions for perennial crops. Some studies deal with this by using lag variables.

#### 15.3.1.2 Types of Data

Analysis, more often than not, will be constrained by the type of data available. The data requirement will also depend on the unit of analysis. If the problem entails the effect of land policy on the country, a time series of the country's socio-economic data should be used. If the problem entails the effect of land policy on farmer behaviour/decision-making/agricultural output, panel data or a repeated cross-section of farmer data should be used. In all these cases, the data series should span the period *before* the year of policy implementation until *after* the year of policy implementation to syphon out the effect. This may require the use of secondary data. Moreover, if the problem entails only a specific group of farmers/farmer households, a cross-section of data comprising both the groups of affected and unaffected farmers may be used. In this case, primary data can be used.

Another important dimension is whether one is interested in studying the long-term impact or short-term effects. Obviously, for long-term impacts, there must be a reasonable time series of data that spans a few years before and after the policy implementation. If the interest is in short-term effects, data spanning a couple of seasons after the policy may be good enough.

Land policies, while having a long-term impact, could also have immediate effects as they change the decision-making behaviour of people. Cross-section data will be helpful in identifying immediate responses. However, there must be a cross-section of data before and after the policy is implemented in order to infer the effect of the policy.

### 15.3.2 Production Function Approach

A production function approach can be applied to study the effects of various land policies that have an effect on agricultural productivity/production. Below, an example of how to econometrically analyse the effect of land fragmentation and land ownership is discussed. Reduced forms of the production functions may be used if policy variables can be approximated with an input used in production. Since there exists a corresponding dual cost function for production functions, cost functions can also be estimated with input costs as explanatory variables. As cost data are more commonly available than production data, cost function estimation is a popular alternative.

#### 15.3.2.1 Land Fragmentation

When a household operates a number of owned or rented non-contiguous land plots at the same time, it is referred to as land fragmentation. Three variables determine the level of land fragmentation: farm size, number of plots, and size of plots. Fragmented land is a common feature of developing-country agriculture that often is a result of a process of subdivision of land through inheritance.

Fragmented land is considered a drawback to the agricultural development of a country, given the negative impact on productivity and costs. Productivity is negatively impacted as fragmented small plots are an obstacle to mechanisation, reduce the scope for irrigation and soil conservation investments, and increase land 'wasted' for access roads and boundaries. Increased costs occur in a situation of scarce labour or when farm households must manage and travel among several distant land plots as this increases transportation costs and demands more of the farmer's time, thus lowering labour productivity and increasing the difficulty in supervising farm labour. In effect, land fragmentation introduces a lot of inefficiencies to agriculture. Land consolidation is often proposed as a policy alternative to address the issue of land fragmentation. Land consolidation refers to the process of reallocating land parcels, with the aim of allowing landowners to obtain larger parcels at one or more places, in exchange for their former smaller and fragmented land plots.

Land fragmentation is a common issue discussed in Sri Lankan agriculture. The majority of farms operate in multiple small plots (Wickremaarachchi and Weerahewa 2016). Around 47 per cent of agricultural holdings operate on less than a quarter-acre of land (Department of Census and Statistics 2015). The issue has often been highlighted as a hindrance to increasing agricultural productivity, with land consolidation proposed as a way of encouraging private investors to invest in agriculture.

Econometric analysis can be used to provide empirical evidence to support policy decision-making on the impact of fragmented land and the need for land consolidation. This requires empirical estimation of a production function to assess the effect of land fragmentation on the agricultural productivity of a farm. Note that the unit of analysis here is a farm, not a land parcel. A land parcel may be used as a unit of analysis if the problem entails assessing the effect of land size on land productivity.

$$Y = f(X_1, X_2, X_3, X_4, X_5) \tag{15.6}$$

where

$Y =$ agricultural productivity

This may be expressed in quantity form or value form. If it is in quantity form, it is the total farm output. If it is in value, it would be the total value of farm output. If the farm produces more than one output, then it becomes difficult to express productivity as a quantity produced per farm. In this situation, the total value of farm output is a more appropriate measure (variable) for farm productivity. The quantities or values used should be for the past year or season.

$X_1$: farm labour

This may be the number of people working on the farm, both hired and family labour, used in a particular year or season. If some workers are part-time workers, then fractions may be considered in calculating labour. To be more precise, the number of labour days or labour hours per year may be used.

The following function specification may be selected:

$X_2$: fertiliser

The amount of fertiliser applied per year or the cost of fertiliser per year may be used.

$X_3$: water

If cultivation is rain fed, it is difficult to give a quantity or value. If cultivation is irrigated, then the amount of water may be used as cubic feet per year/season. If water is purchased, the water bill of the farm (excluding water consumed by the household) may be used.

$X_4$: capital

Since machinery is a fixed cost of the farm, the cost of buying machinery should not be used as a variable. Instead, the service flow per year from the machines should be used. There are various ways to calculate the annual service flow. For example, a simple way to calculate the service flow of a tractor would be

$$\text{Annual cost} = (\text{total cost of the tractor} - \text{scrap value})/\text{life time} \tag{15.7}$$

The service flow per year of all farm machinery should be added. If farm machinery is rented, the rental fee should be used as the annual cost of capital.

$X_5$: land fragmentation

The average plot size and the average number of plots per farm may be used as measures of land fragmentation. Alternately, a fragmentation index can be used. An index could be created as a function of farm size, the number of plots per farm, and plot sizes (e.g. Simpson Index of Blarel et al. 1992).

$$\text{Simpson Index} = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \tag{15.8}$$

where $a_i$ is the individual plot size and $A$ is the size of the farm.

The econometric specification could be a linear function, exponential function, lin-log function, or log-log function.

An example of a log-log specification is as follows:

$$\begin{aligned}\log\ (\text{productivity}_I) = {} & \beta_{0i} + \beta_{1i}\ \log\left(\text{labour}_i\right) + \beta_{2i}\ \log\left(\text{fertiliser}_i\right) \\ & + \beta_{3i}\ \log\left(\text{water}_i\right) + \beta_{4i}\ \log\left(\text{capital}_i\right) \\ & + \beta_{5i}\ \log\left(\text{farm size}_i\right) + \beta_{7i}\ \log\left(\text{number of plots}_i\right) \\ & + \varepsilon_i \end{aligned} \tag{15.9}$$

where $i$ is the individual farm and $\varepsilon$ is the error term.

#### 15.3.2.2 Land Ownership

Land ownership is argued to have a relationship with the effort a farmer/tenant takes in farming. Effort or management is input to agricultural production. To see if a particular land tenure policy has an effect on agricultural productivity, a production function could be estimated. The same type of data as discussed for land fragmentation above could be used. Land ownership type may be modelled as a proxy for the effort a farmer is exerting in farming.

There could be two types of farmers: those who cultivate their own land and the tenant farmers, who cultivate someone else's land. This could be modelled as a dummy variable where it would take value '1' for owned land and '0' for rented land (or otherwise).

The econometric model in a log-log specification will be as follows:

$$\begin{aligned}\log\ (\text{production}) = {} & \beta_0 + \beta_{1i}\ \log\left(\text{labour}_i\right) + \beta_{2i}\ \log\left(\text{fertiliser}_\text{i}\right) \\ & + \beta_{3i}\ \log\ \left(\text{water}_i\right) + \beta_{4i}\ \log\left(\text{capital}_\text{i}\right) + \beta_{5i}\ \text{own} \\ & + \varepsilon_i \end{aligned} \tag{15.10}$$

where $i$ is the individual farm and $\varepsilon$ is the error term.

#### 15.3.2.3 Simulation

The estimated model may be simulated to see how close the estimated data are to the data observed in real life by multiplying the input variables with the estimated coefficients and obtaining the predicted output (dependent variable). This should be compared with the actual observed output for the same input use. If the values are close, the econometric model is able to simulate the actual data.

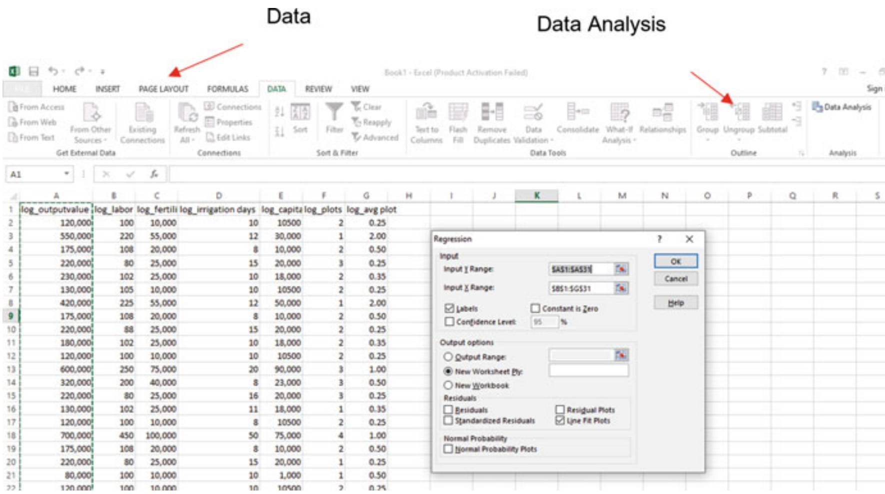
## 15.4 Assignments

1. Estimate the effect of land ownership on agricultural productivity.
   Use the farm cost data to estimate the effect of land ownership on farm production. Comment on the effect of land ownership on farm production. The data is available at https://drive.google.com/file/d/1HTc0zaYq2XPp05csgWYWX2WuWtoXYjde/view?usp=sharig:
   (a) Create a dummy variable for 'ownership', where 'owned' land gets a value of '1' and 'rented' land gets a value of '0'.
   (b) Create log variables for other variables.

(c) Run regression of log of farm production on log of inputs and ownership dummy. Regression analysis may be carried out in Excel. In an Excel spreadsheet in which you have entered data, go to Data, Data Analysis.[2]

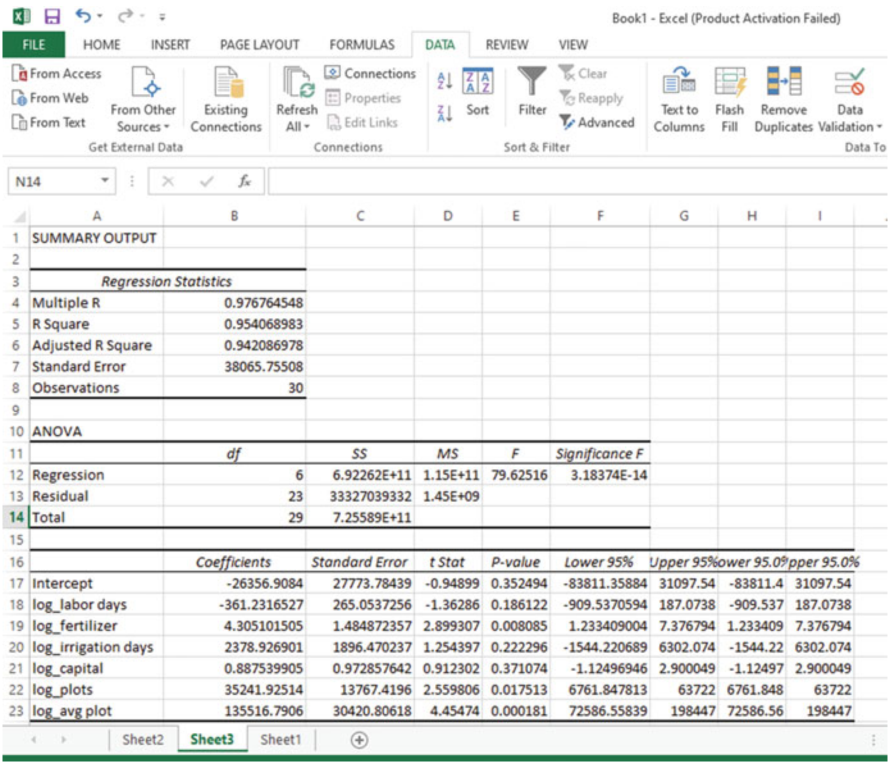
1. Select regression.
2. Select *Y* range.
3. Select *X* range.
4. Click OK.

Here is a screenshot of the data and the regression dialog box:




The regression output will appear in a separate sheet as follows:

[2]Analysis ToolPak is available in all versions of Excel from 2003 to 2019 but is not enabled by default. It needs to be turned on manually. Follow the instructions given in this link to manually add ToolPak: https://www.excel-easy.com/data-analysis/analysis-toolpak.html




SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.976764548 |
| R Square | 0.954068983 |
| Adjusted R Square | 0.942086978 |
| Standard Error | 38065.75508 |
| Observations | 30 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 6 | 6.92262E+11 | 1.15E+11 | 79.62516 | 3.18374E-14 |
| Residual | 23 | 33327039332 | 1.45E+09 | | |
| Total | 29 | 7.25589E+11 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *ower 95.0%* | *pper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -26356.9084 | 27773.78439 | -0.94899 | 0.352494 | -83811.35884 | 31097.54 | -83811.4 | 31097.54 |
| log_labor days | -361.2316527 | 265.0537256 | -1.36286 | 0.186122 | -909.5370594 | 187.0738 | -909.537 | 187.0738 |
| log_fertilizer | 4.305101505 | 1.484872357 | 2.899307 | 0.008085 | 1.233409004 | 7.376794 | 1.233409 | 7.376794 |
| log_irrigation days | 2378.926901 | 1896.470237 | 1.254397 | 0.222296 | -1544.220689 | 6302.074 | -1544.22 | 6302.074 |
| log_capital | 0.887539905 | 0.972857642 | 0.912302 | 0.371074 | -1.12496946 | 2.900049 | -1.12497 | 2.900049 |
| log_plots | 35241.92514 | 13767.4196 | 2.559806 | 0.017513 | 6761.847813 | 63722 | 6761.848 | 63722 |
| log_avg plot | 135516.7906 | 30420.80618 | 4.45474 | 0.000181 | 72586.55839 | 198447 | 72586.56 | 198447 |

(d) Interpret the coefficient estimates. Is farm production of owned farms higher than rented farms?

(e) If you are using STATA software, type the following:

reg log (name of then *Y* variable) log (name of the $X_1$ variable) log (name of the $X_2$ variable)

Press *Enter* to get the regression output.

2. Collect data from 50 crop farms for the following variables in a selected area village or a Grama Niladhari Division:
   (a) Value of total farm output sold in Maha 2018
   (b) Number of labour days used, including family labour in Maha 2018
   (c) Cost of fertiliser for Maha 2018
   (d) If irrigated, number of days irrigated
   (e) Rent/cost per year of machinery
   (f) Number of cultivated plots per farm
   (g) Average size per plot

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