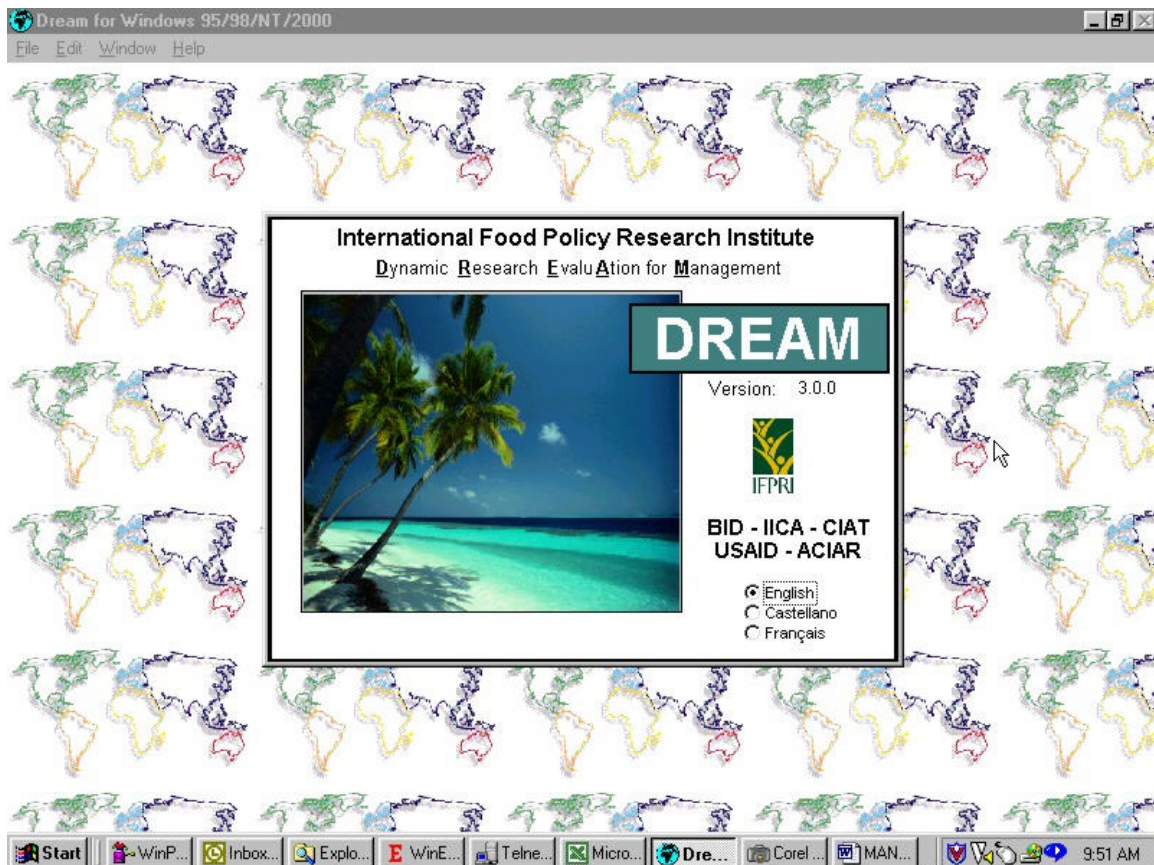


Dynamic Research EvaluAtion for Management

DREAM Version 3

A user-friendly system for estimating the magnitude and distribution of the economic benefits of agricultural research and development



USER MANUAL

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The first Windows version of **DREAM** was an IFPRI output for the project "Strengthening Agricultural Research Priority Setting Capacities and Applications in Latin America and the Caribbean," financed by the Interamerican Development Bank (IDB), coordinated by the Interamerican Institute for Cooperation for Agriculture (IICA), and implemented by IICA and IFPRI. The International Center of Tropical Agriculture (CIAT) also provided significant support for that version.

The current version has evolved thanks to additional financial support from IDB, USAID, ACIAR, and PROCISUR. Many individuals have contributed to **DREAM** in various ways but we would like to thank, in particular: Julian Alston, Flavio Avila, Ruben Echeverria, Veronica Gottret, Deborah Hill, Luis Macagno, Hector Medina, and Phillip Pardey.

¹The system was designed by Stanley Wood and Wilfred Baitx and was implemented and programmed by Wilfred Baitx, Stanley Wood and Liangzhi You. Previous DOS versions of **DREAM**: Version 1.2 (March 1997). Financial Support — BID, IICA, IFPRI. Programming — Stanley Wood. Version 1.0 (November 1995). Financial Support — ISNAR, IFPRI. System Design — Stanley Wood and Phil Pardey. Programming — Stanley Wood and Ulrike Wood-Sichra.

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INTRODUCTION

Welcome to **DREAM**. **DREAM** is designed to evaluate the economic impacts of agricultural research & development (R&D) for a broad range of policy, market, technology, and adoption conditions. The objective is to provide R&D analysts with a practical means of generating relevant and structured information to support strategic decision making. Typically, these decisions relate to agricultural R&D policy formulation, priority setting, and resource allocation.

It is impossible to quantify the economic impacts of all kinds of research. **DREAM** focuses primarily on the evaluation of new technologies or practices applicable at the farm level. But while the immediate impacts of R&D often arise from technology-induced changes in yield potential and production costs at the farm level, the broader economic effects also depend upon a range of biophysical, social, and market factors, for which **DREAM** requires the user to provide quantitative estimates. The process of obtaining information on technology and adoption scenarios from scientists, extension workers, and others is critical to the success and reliability of the analysis. A discussion of data-collection methods is, however, beyond the scope of this manual, and we recommend the reader to consult other sources such as Alston, Norton, and Pardey (1995).

DREAM can handle very simple to quite complex problems using a standardized interface. Analytical options include multiple regions, supply and demand dynamics, and a range of options to represent technology transfer and adoption. Thus, **DREAM** provides a framework for exploring various kinds of policy, technology, extension, and trade issues, and, the challenge for the analyst is to develop a clear understanding of the model's capabilities, assumptions, and limitations. Without such an understanding it is difficult to formulate real-world problems in relevant analytical terms and to properly interpret the resulting outputs.

We hope **DREAM** will be a significant contribution to the long-term effort of improving the tools available to research analysts for exploring and explaining the socioeconomic and environmental impacts of agricultural research investments. For this reason, we invite users to contact us with comments, problems of use or interpretation, or any other suggestions that could improve the utility of this package. Through such a dialogue the **DREAM** might become a successful reality!

INSTALLATION in Windows 95/98/2000 and Windows NT

System Requirements

DREAM is designed to run under Windows 95/98/2000 or Windows NT. As a minimum the program requires a 486DX 66Mhz processor (but in practice a Pentium 300Mhz or higher is strongly recommended), a mouse, 16MB RAM and 10MB of hard disk space (allowing for the required program modules and the data directories "\database\" and "\example_database\").

A minimum screen resolution of 640x480 is required, but 800x600 is preferred, and the display system should be capable of displaying at least 256 colors.

The program does not have hardware or software protection.

Installation of **DREAM**

From CD

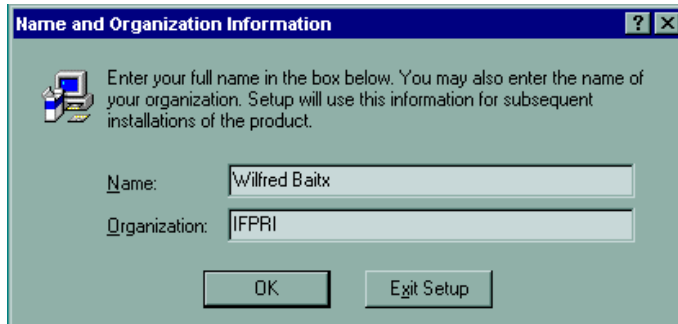
Insert the **DREAM** CD into your CD drive. Windows should detect the **DREAM** CD and the following screen will appear. Clicking **INSTALL** will start the installation. Users with internet connectivity can also browse **DREAM** website, and all users can view the **DREAM** manual.



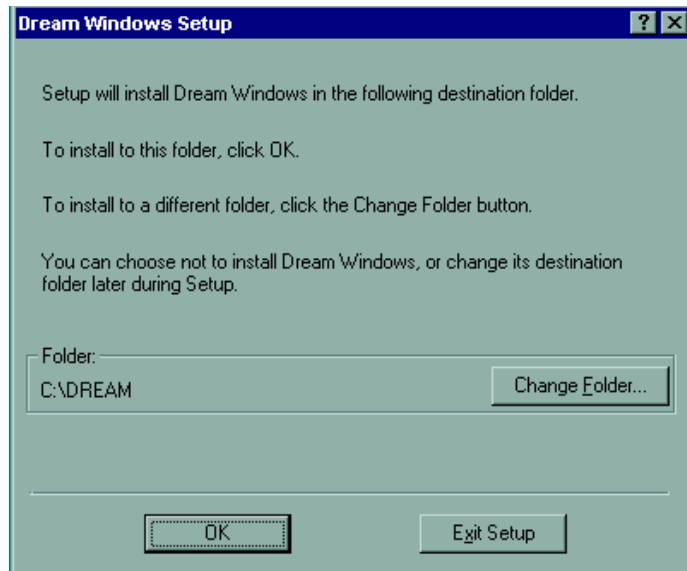
From Internet or FTP Download

DREAM is accessible via the IFPRI website (<http://www.ifpri.org/dream.htm>). The download site contains detailed instructions in the README.TXT file. The program is stored in a compressed format (Winzip), and the user must expand the files into a temporary folder. Click on the *Windows* "Start" button, then click *Run* and *Browse*, and locate the program "DRSETUP.EXE" in the temporary folder. Press *OK* to run the setup program and begin the installation process.

For all Installations

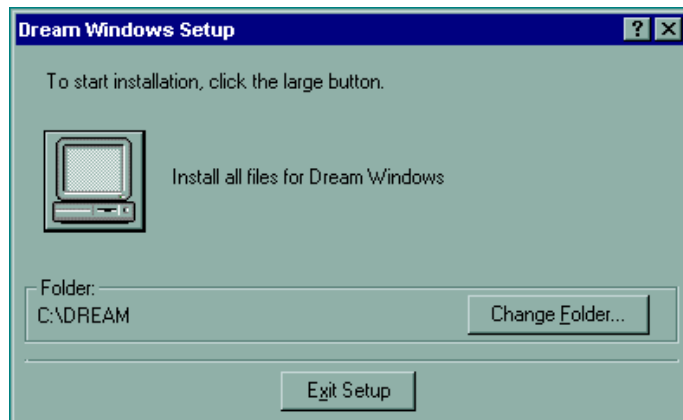


A box will be displayed asking for the name of the user and of the organization. This information is recorded by Windows and will be presented whenever the program is updated. To change the information, the program must be reinstalled.




A *Setup* dialog box will then prompt the user to specify a destination folder for the **DREAM** installation. The default folder will be "C:\DREAM," but any other folder can be selected.

Note that the installation program will create a subdirectory called *DATABASE* within the folder selected for the installation of **DREAM**. The database subdirectory (e.g. C:\DREAM\DATABASE) is required to run the program.



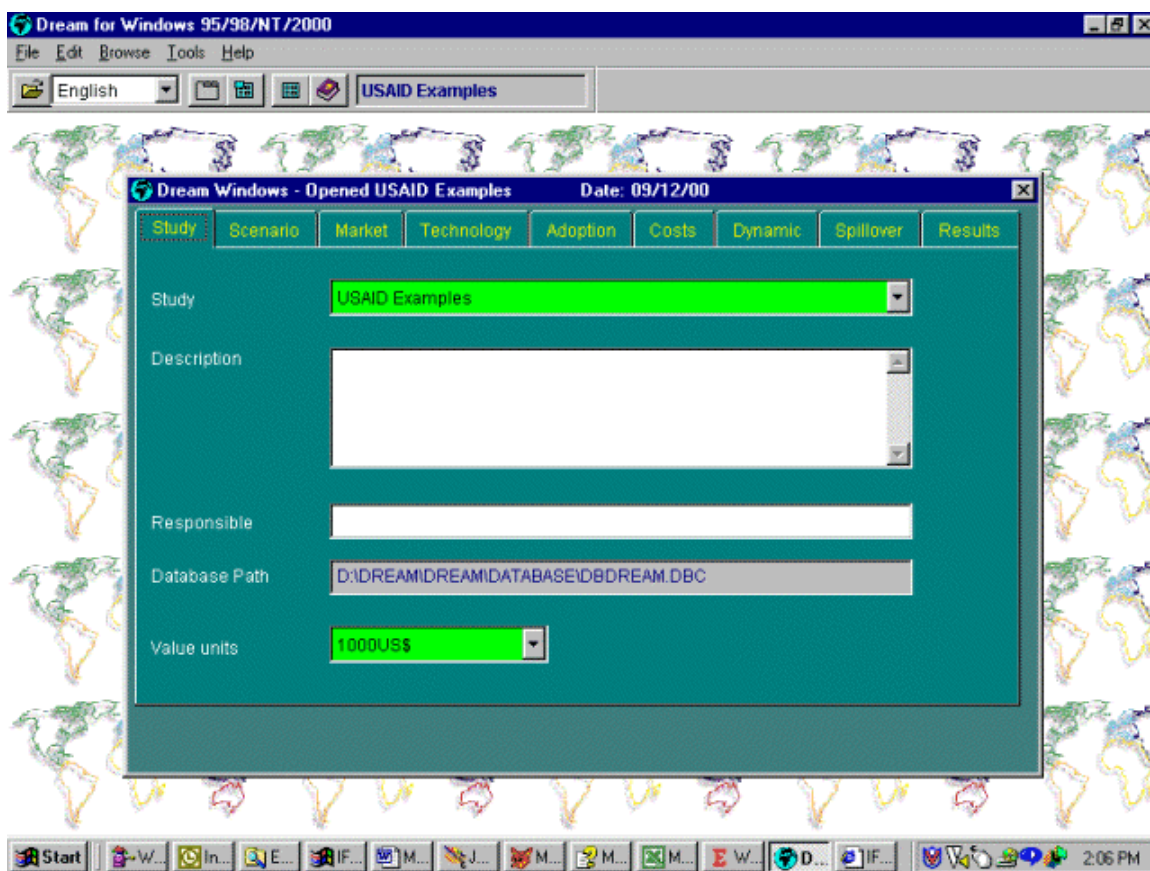
Clicking over the large button on the *Setup* dialog box will start the installation process. If the program is being installed from diskettes, the installation will ask for subsequent diskettes as they are needed.

Creating a shortcut to DREAM.

Right click anywhere on the Windows desktop, select *New* and then *Shortcut* and when the *Create Shortcut* window appears, select *Browse* and look for the *DREAM.EXE* program in the directory you have specified for your **DREAM** installation. Rename the icon, e.g. **DREAM**, and then *Finish* the creation operation. The **DREAM** globe icon () should appear on your desktop and you may drag it to any convenient location. The next time you wish to run **DREAM**, simply double-click this icon.

STRUCTURE AND LOGIC OF THE INTERFACE

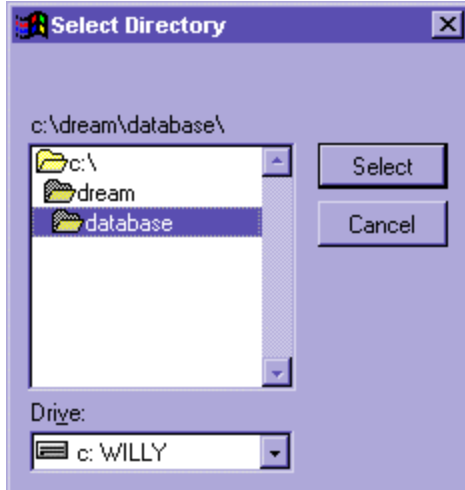
When **DREAM** is running, a bar menu is displayed at the top of the screen as well as a Data Editor window in the center of the screen (as shown). The Data Editor window is divided into "data pages" that can be selected simply by clicking on their title tab. In this manual, a page is referred to as **Page**, and a field as *Field*. Thus, a complete reference for a data field is, for instance "**Scenario:Product**", the *Product* field on the **Scenario** page.




Some fields are color-coded. Fields with white background are optional. Colored fields highlight the minimum data that must be provided in order for a **DREAM** analysis to run correctly. For instance, on the **Market** data page, the user can provide information to characterize production, consumption or both. If production (or consumption) data is provided, it is necessary to fill out at least the three colored fields *Quantity*, *Price*, and *Elasticity*. However it is also possible that a region contains neither production nor

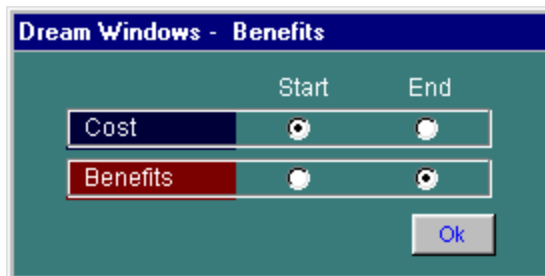
consumption (if the region has been defined only to represent a technology source). In that case, the entire **Market** page remains blank.

Database Selection



DREAM stores and manages data on multiple evaluation "Studies." In turn, each study provides access to groups of related "Scenarios." All this information is included in a single database in a single folder. By default, the active **DREAM** database is located in the folder '\DREAM\DATABASE.' It is possible to access other **DREAM** databases via the main menu, under the menu *File* and then *Change Database* (or simply click on the *Change Database* icon  on the main toolbar). This data storage and access interface allows for easy swapping or sharing of datasets between users. This directory is also the default folder for saving and opening files inside **DREAM**.

Discount Rule



The discount rule specifies whether the benefits and costs are considered to occur at the start or the end of a time period. By default costs are incurred at the start of a period and benefits at the end. Change the setting by clicking *Discount Rule* on the *Tool* menu. The window shown on the left then appears. Choose the appropriate discounting rules for costs and benefits. This setting remains in force unless changed again by the user or **DREAM** is reinstalled.

The Right Hand Mouse Button (RHB)

In many situations, clicking the right hand mouse button provides access to a variety of data management possibilities. For instance, when the mouse cursor is inside the fields **Study:Study** or **Scenario:Scenario**, right clicking provides access to such possibilities as creating, renaming, copying and deleting.

Similarly, on the pages **Scenario**, **Market**, **Technology**, **Adoption**, **Costs**, and **Dynamics** right clicking provides access to browse windows that display multiple records to facilitate comparing and editing data. It is also a convenient way to enter or edit large amount of data. A sample browse window for **Market** page is shown in the following.

Scenario: LAC - AI-Maize										
Region	Region	Group	Price	P.Change	P.Qnty	C.Qnty	P.elast1	P.elast2	C.elast1	
Argentina	Argentina	Southern Cone	113.38	0.80	10841.38	5958.47	1.000	0.000	-0.500	
Bolivia	Bolivia	Andean	113.38	0.80	497.80	423.78	1.000		-0.600	
Brazil	Brazil	Southern Cone	113.38	0.80	32330.78	32851.55	1.000		-0.500	
Chile	Chile	Southern Cone	113.38	0.80	922.51	1316.58	1.000		-0.500	
Colombia	Colombia	Andean	113.38	0.80	1085.14	1917.10	1.000		-0.500	
Costa Rica	Costa Rica	Mesoamerica	113.38	0.80	33.88	318.91	1.000		-0.500	
Ecuador	Ecuador	Andean	113.38	0.80	563.83	557.23	1.000		-0.500	
El Salvador	El Salvador	Mesoamerica	113.38	0.80	614.00	731.55	1.000		-0.500	
Guatemala	Guatemala	Mesoamerica	113.38	0.80	1227.61	1359.87	1.000		-0.600	
Haiti	Haiti	Caribbean	113.38	0.80	206.98	220.55	1.000		-0.500	
Honduras	Honduras	Mesoamerica	113.38	0.80	801.40	636.58	1.000		-0.500	
Dominican Republic	Dominican Republic	Caribbean	113.38	0.80	38.24	675.27	1.000		-0.500	
Mexico	Mexico	Mesoamerica	113.38	0.80	17910.83	18981.53	1.000		-0.500	
Panama	Panama	Mesoamerica	113.38	0.80	108.47	247.42	1.000		-0.500	
Paraguay	Paraguay	Southern Cone	113.38	0.80	541.67	450.72	1.000		-0.500	
Nicaragua	Nicaragua	Mesoamerica	113.38	0.80	277.13	302.21	1.000		-0.600	
Peru	Peru	Andean	113.38	0.80	663.18	1435.94	1.000		-0.500	
Cuba	Cuba	Caribbean	113.38	0.80	65.83	195.13	1.000		-0.500	
Uruguay	Uruguay	Southern Cone	113.38	0.80	108.82	188.60	1.000		-0.500	
Venezuela	Venezuela	Andean	113.38	0.80	1023.33	2311.78	1.000		-0.500	

Related Windows and Dialog Boxes

A progress bar will appear whenever time is needed for a process to be completed.

The **Market**, **Technology**, **Adoption**, **Costs**, **Dynamics**, and **Results** data pages have *Scenario* and *Region* selection list boxes that allow data for any scenario or region to be selected and displayed on the current page form.

A BRIEF STEP-BY-STEP GUIDE TO USING DREAM

Note

- A new database is not empty. By default, a new database contains one study (*Study 1*) which includes one scenario (*Scenario 1*) that, in turn, contains a single region, (*Region 1*). These can be renamed by placing the cursor over the name and right clicking.
- Colored fields indicate the minimum data that needs to be provided in order to complete a data- entry page (noting that, depending on the type of the region, some pages may be optional).
- In many cases, it is possible to create, rename, and delete data using a menu activated by right-clicking the mouse.

Step-by-Step Guide to using DREAM

1. Start the **DREAM** program and click to select the preferred language.
2. **Discount Rule** (Optional): Change the discount rule option if the default (cost at the start of a time period and benefit at the end) differs from your normal practice. This can be done by selecting *Discount Rule* in the *Tool* menu. This only needs to be done the first time you use **DREAM**.
3. **Study**
Select an existing study from the study selection list box or create a new study (by right-clicking with the mouse cursor located in the field "*Study*").
4. **Scenario**
Select the **Scenario** page by left-clicking on the Scenario page tab. After the **Scenario** page is selected, enter the following data:
 - a. *Name*
Right-click within the *Scenario Name* field to create a new scenario, or to change the default scenario name to better describe the problem being defined.
 - b. *Commodity*
Select the commodity associated with the scenario. If the required commodity is not in the list, it can be created in the *Commodity Editor*, obtained by right-clicking in the *Commodity* field.
 - c. *Market*
Select one of the four market options (the default is *multiple horizontal markets*). Selecting the *vertical market* option automatically generates three fixed "*regions*" named Farm, (Post-harvest) Services, and Consumer, (although it is possible to rename the areas described below).
 - d. *Regions*
Right clicking on an existing region name displays a menu for managing region definitions for the current scenario. The relevant operations will depend upon the market type selected for the scenario.
 - In the case of a *small, open economy* or a *closed economy*, (optionally) rename the single region by right clicking on the region name.
 - In the case of the *vertical model*, (optionally) rename the three levels via the right-click menu. The default names are: Farm, Service, and Consumer. *Service* implies all post harvest operations between the farm and the final consumer. (e.g. transportation and processing)
 - In the case of *multiple markets*, (optionally) rename the first region and then, using the same right-click menu, create additional region.
 - e. *Other data*

Use the *spinners* to define the *Base Year* for the analysis (which also corresponds to the year of the initial market equilibrium data entered in the **Market** data page), the *Simulation Period*, and the *Real Discount Rate* (the nominal interest rate, net of inflation).

5. **Market**

Enter, region by region, the appropriate market data for the defined base year. The range of information required depends on the specific market model defined in the **Scenario** page (see 4c above). It is possible to change the currently displayed region using the region navigation box located in the lower part of the Data Editor window. If elasticities, growth rates, taxes, or subsidies are expected to change over time (positively or negatively) the user must select (a) a constant increment every year; (b) a final value attained at the end of the simulation period; or (c) the *Manual* option, that allows the users to specify unique value for each year using **Dynamics** page.

6. **Technology**

For regions that will generate new technology during the simulation period, select the **Technology** data page (again, the navigation button at the bottom of the window allows different regions to be selected). Enter the number of years required to perform the R&D, the probability of R&D success, and the anticipated change in the unit cost of production (relative to the base year) if the R&D is successful and the resulting technology fully adopted (Refer to the **Technology** page description for further details on entering this type of data).

7. **Adoption**

For production regions in which new technologies will be adopted, select the **Adoption** data page. As a minimum, the user must define the time expected to elapse from the release of a new technology until the maximum adoption level is attained (the adoption lag), and the expected maximum adoption level itself, expressed as a percentage of the production within the region that will be produced using the new technology.

8. **Costs**

If data are available on the costs of research, development, and dissemination of the new technology, this information can be entered in the **Costs** data page for each region. If no cost data are available, **DREAM** is only able to calculate the gross benefits of R&D. In order to initialize cost data entry for a region, click the button *Label years* at the bottom of the page.

9. **Dynamics**

The **Dynamics** data page shows the values of the specified market parameters in each year of the simulation period: elasticities, autonomous growth rates, technology-induced supply shifts (*K*'s), and policy distortions (taxes and subsidies). These values can change over time if the user has specified such changes in the **Market** data page. The **Dynamics** page allows the user to review and, if necessary, further edit these annual values.

10. **Spillover**

Here, the user can specify whether or not the scenario includes region-to-region technology spillover. By default, spillover does not take place. If the scenario is to include a consideration of technology spillover, the user must click on the *Spillover* check box, and then enter a technology transfer coefficient for each pair of regions (the default values are 0 [zero] between different regions, and 1.0 inside the same region), and the lag time needed for the technology transfer to occur. By default, **DREAM** considers that technologies spilling into a region from other regions are substitutes, and will choose to adopt the single technology having the greatest local impact. (see **Spillover** page description for further details).

11. **Results**

To analyze a **DREAM** scenario, the user must click the *Run* button, on either the **Scenario** or the **Results** pages. A dialog box will appear in which the user can define the preferred format for the results.

There are two scenario output formats. In the *Table* format (default) the simulation results are added to a table (within DREAM database) containing the results of all scenarios for all studies. Users can access any results stored in the table using the scenario drop-down box in the **Results** page. Results

can be reviewed on-screen or sent to the printer. Every time a scenario simulation is made with output specified as *Table*, the new results replace (overwrite) the existing results held in the results database for that scenario.

The alternative output format is a single text (ASCII) file, which can be reviewed on-screen, named, and saved on the hard disk. This format is useful for examining the detailed scenario results, viewing all the results in a single file, and for passing those data to other packages, e.g., spreadsheet or word processor.

Table 1: Overview of Data Needs by Region Type

Region Type	Data required from the user						Examples
	Market		Technology		Technology Spillover		
	Production ^a	Consumption ^a	R&D	Adoption	Spillin	Spillout	
1. Standard region	✓	✓	✓	✓	(✓)	(✓)	Production, consumption, R&D and adoption are all taking place.
2. Production with access to new local technology	✓		✓	✓			A region with an ecologically specific technology, or with a technology directed to small producers.
3. Production with access to new imported technology	✓			✓	✓		There is no local new technology, it must be imported.
4. Production without access to new technology	✓						An agroecological zone or a producer group for which the new technology is not available or useful.
5. Research entity			✓			✓	An IARC. A "region" with no production or consumption that transfers its technology to production regions (such as region types 1, 2, and 8) via technology spillover.
6. Consumption only		✓					Even if a country has been disaggregated into distinct production regions, it may not be necessary to disaggregate consumption. All national consumption can be placed in one region.
7. Positive balance of trade^b		✓					When aggregate production is greater than consumption, an importing (consumption) equilibrium region must be created.
8. Negative balance of trade^b	✓		(✓)	(✓)	(✓)	(✓)	When aggregate production is less than consumption, an exporting (production) equilibrium region must be created.

Table Notes:

Check marks in parenthesis denote optional data.

a. It is always possible to disaggregate production or consumption into separate “regions” to represent different socioeconomic groups, such as commercial or small producers, or urban and rural consumers.

b. Equilibrium regions (Type 7 and 8) are important in multimarket analysis. Aggregate production across all regions must equal aggregate consumption, and equilibrium regions often need to be created to ensure that an overall aggregate balance exists.

STUDY

Purpose of the Page

This is the highest level data page and it allows the user to define "studies" that will contain clusters of analyses ("scenarios"). Each study, thus, is any logical grouping of related scenarios for analyzing the development, adoption, and impact of new technologies. This page contains information such as the name and a brief description of each study, the physical location of the **DREAM** database currently in use, the study author, and the value units used to compare costs and benefits across the different scenarios in each study.

<u>Field</u>	<u>Description</u>
<i>Study</i>	Name of the study—a set of related scenarios. [RHB]
<i>Description</i>	Brief description of the study's content, focus, and any other relevant information.
<i>Responsible</i>	The author of the study.
<i>Database</i>	Location of the DREAM database. See Database Selection on the selection of alternative databases.
<i>Value Units</i>	Defines the units to be used for comparing benefits and costs across scenarios. The default unit is US\$1,000. It is important that all the scenarios in a study are defined using the same value units [RHB].

Right-Hand Button [RHB] Menus (*Study* and *Unit* fields)



The command *Create new* will generate a blank study (Study n , where n is the next available sequence number), having a blank scenario (*Scenario 1*) that contains a single, blank region (*Region 1*).



Right-clicking in the *Value Units* field displays a menu with options to *Create new*, *Rename*, and *Delete*. When choosing *Create new* or *Rename*, a dialog box will appear to allow input/edit.

SCENARIO

Purpose of the Page

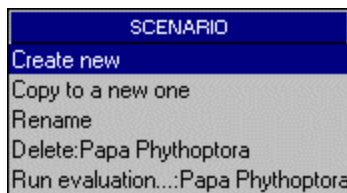
This data page is used to specify and provide access to all the scenarios of a selected study. A scenario is defined as a specific combination of: market model, commodity (or production system) and one or more regions in which new technologies are generated or adopted and the commodity is consumed. It is also possible to define groups of regions for which summary estimates of R&D costs and benefits will be generated. R&D evaluation is made on a scenario-by-scenario basis, and each scenario analysis comprises a simulation over a specified time period. The base year and the simulation time period for each scenario are defined on this page, as is the discount rate for calculating the present values of cost and benefit streams.

<u>Field</u>	<u>Description</u>
<i>Scenario</i>	Scenario dropdown selection list. Right-clicking on a scenario name provides access to <i>Create</i> , <i>Rename</i> , <i>Delete</i> , and <i>Run</i> options. [RHB]
<i>Description</i>	Text fields to allow the entire scenario and each region to be annotated.
<i>Commodity</i>	The commodity or production system associated with the Scenario. [RHB]
<i>Market Model</i>	The market model to be used. There are four options: <i>Horizontal Multimarket</i> (default), <i>Closed Economy</i> , <i>Small Open Economy</i> , and <i>Vertical Market</i> (three levels).

<i>Base Year</i>	The base year for the analysis. It corresponds to the reference year used for the Market (page) data.
<i>Period</i>	The simulation period should include the time required for the generation, dissemination, and adoption of the technology being evaluated. In many cases, the economic benefit of a new technology will be derived over an extremely long period, and the end point of the simulation period must be arbitrarily defined. In practice, discounting renders the estimated present value of benefits negligible beyond, say, 30 years.
<i>Discount Rate</i>	Real discount rate (nominal interest rate minus inflation rate).
<i>Region</i>	Create a new region, or rename or delete existing regions [RHB].
<i>Region Groups</i>	Assign regions to a user-specified group (optional). The left section (spinner) assigns a group to the currently highlighted region. The right field defines the name of the group [RHB].

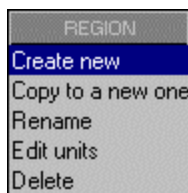
Right-Hand Button [RHB] Menus

Scenario Field



Right-clicking the *Scenario* field displays the menu shown here. *Create new* will generate a blank scenario (*Scenario n*, where *n* is the next available sequence number), containing a blank region (*Region 1*), and will display a dialog box to allow the new scenario and region to be named. *Copy to a new one* will copy all data for the currently selected scenario and will display the *Rename* dialog box to allow the new scenario to be named. *Rename* will display the *Rename* dialog box for the currently selected scenario. *Delete* will delete the currently selected scenario and all of its related data, e.g., *regions*, *market data*, and *spillover*. Since a study must always contain at least one scenario, it is not possible to delete the last remaining scenario (to do this, the study must be deleted). *Run* will run a **DREAM** simulation for the selected scenario.

Regions Field



From the menu displayed by right-clicking on the name of any existing region, *Create new* will create a blank region that the user must name. *Copy to a new one* will display a naming dialog box after creating a new region and copying all the data from the selected region to the new region. *Rename* will display the *Rename* dialog box for the selected region. *Delete* will delete the selected region and all the lower levels of related data for that region (this option will not be available if only one region exists).

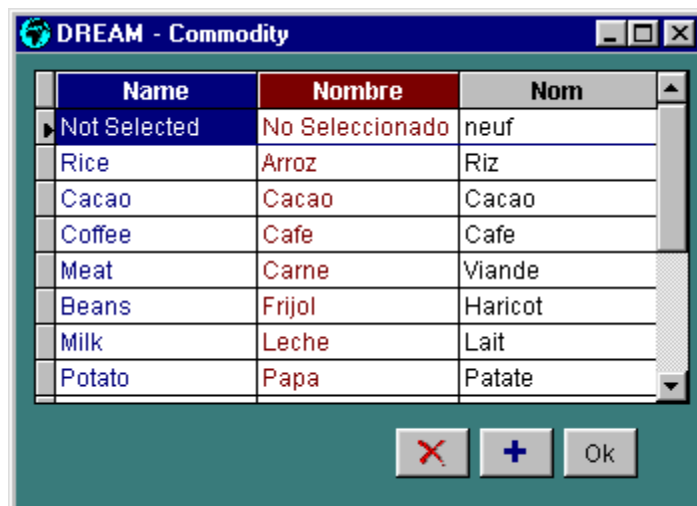
Groups Field

When the cursor is located inside the right-hand side of the *Region Groups* field, right-clicking will display a Group menu. Use this menu to create new region groups or to delete the existing groups. **DREAM** automatically names the new group as "Group ##" where "##" is the next group number available in this scenario. Users can highlight and change the group name in the *Groups Field* directly. The menu works with two restrictions: first, if there is only one group, it cannot be deleted. Second, only the last group on the list can be deleted. For instance, group three cannot be deleted if there is a group four. Group four will have to be deleted first, and then group three.



Commodity Field

The commodity list is obtained by right-clicking the *Commodity* field, and can also be accessed using the toolbar button *Product Editor* on *Tools* menu.



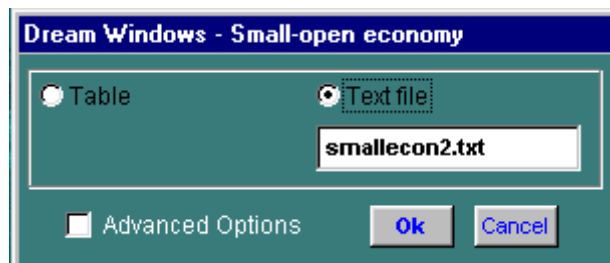
In the Product Editor, commodities can be created or deleted. The editor window has 3 fields, corresponding to the three languages of the current **DREAM** version.

Related Windows and Dialog

Boxes

Output Options

When *Run* (a scenario) is selected, the report generation window presents two output options. The *Table* option sends the analysis outputs to a database table containing results for all studies and scenarios. Individual reports can be generated from this table via the [Results](#) page. If, on the other hand, the *Text file* option is selected, a field will appear asking the user for the name of the text file to be generated. The default name for the report file is "Results.TXT." By default, the text file is saved in the same folder as the current **DREAM** database. If a report file already exists with the specified name, **DREAM** will provide a warning message. If the file is overwritten, all the original information will be lost. A check box with "Advanced Options" also appears. That allows multiple simulations to be made within a single model run. "Advanced options" is only available for text-file output and horizontal multi-market.

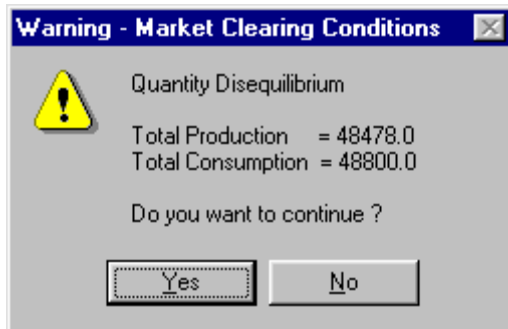


Edit Units

The *Units* window provides access to detailed data about the value, quantity, and price units for each region. The value unit is the unit specified on the **Study** page, and it cannot be modified here (it can be changed on the [Study](#) page). To maintain the unit consistency, the following identity must hold: $\text{scale} \times \text{quantity} \times \text{price} = \text{value}$. For example, with value unit $1000\text{US\$}$, quantity unit $1000T$, price $\text{A\$/T}$ (A\$: Australian dollar), the scale must be 0.57 if the exchange rate is $0.57 \text{US\$/A\$}$. Or with value unit $1000\text{US\$}$, quantity T , scale is 1 , then the price unit must be $1000\text{US\$/T}$ (which is the same as $\text{US\$/kg}$). This window is useful for regions (countries) with different monetary units, or scaling down (or up) the price, cost and benefits. This window also allows users to change region names.

Region	Value	Quantity	Price	Scale
Kenya	1000US\$	1000 T	US\$ / T	1.000
Tanzania	1000US\$	1000 T	US\$ / T	1.000
ROW	1000US\$	1000 T	US\$ / T	1.000

Warning Message



In the case of *Horizontal Multimarkets*, total production and total consumption must be in equilibrium across all regions. If the data entered do not satisfy this condition, a *Warning* dialog box appears displaying the (unequal) aggregate values. It is advisable to note these differences and revise the market data accordingly. If the differences are small, it is possible to continue the analysis, but the simulation results would only be indicative.

Advanced Options

Advanced Options

Advanced Options to override region specific data shown in the Data Editor, as well as to set up multiple runs of a single scenario

Initial Equilibrium Price Override

No override (default) Fix all initial prices to

Price Evolution (Exogenous Growth) Override

No override (default) - e.g. variable real prices
 Constant real prices - no exogenous growth
 Constant real prices - exog. supply growth = demand growth

Multiple Runs with Technology Shifts

Single run - shifts as defined in Data Editor
 Multi-run - region specific k's
 Multi-run - same k for all regions(%)

R&D Impacts One-by-one All-but-one

Transmission Default Override all

Multiple Runs (Spillover)

Single run - spillover defined in Data Editor
 Runs with and without spillover

Spillover Coefficient

Default Override all

Exclude "X ..." Regions from Totals

This page allows users to temporarily overwrite the data in the Data Editor as well as to set up multiple runs of one scenario. Scenario-wide changes can be made to: initial prices, exogenous growth rates, technology shifts, transmission coefficients, and spillover coefficients. For technology shift options, multiple runs can apply technology shifts (k's) to each region in turn (*one-by-one*) while setting all other regions' shifts to zero. The *All-but-one* option keeps one region without a technology shift while all other regions are allowed to shift.

It is possible to prevent the costs and benefits associated with any given region from entering the scenario result totals. This is done by defining those regions with names prefixed by "X_" on **Scenario** page. On the **Advanced Option** page, check the exclusion field (the last check box on this page).

MARKET MODEL - 1 (Multiple Horizontal Markets)

Dream Windows - Opened LAC -A1 Date: 01/18/01

Study Scenario **Market** Technology Adoption Costs Dynamics Spillover Results

Initial Price **113.38** US\$ / T Transmission 0.80

PRODUCTION

Quantity **10841.38** 1000 T

Elasticity

1.000 0.000 Increment End Value Manual

Growth Rate (%/year)

0.00 0.00 Increment End Value Manual

Tax/Subsidy (%/year)

0.00 0.00 Increment End Value Manual

CONSUMPTION

Quantity 5558.47 1000 T

Elasticity

-0.500 0.000 Increment End Value Manual

Growth Rate (%/year)

1.12 0.68 Increment End Value Manual

Tax/Subsidy (%/year)

0.00 0.00 Increment End Value Manual

Scenario LAC - A1-Maize Region Argentina Commodity Maize

Purpose of the Page

The **Market** data page allows the user to define the market conditions prevailing in the base year of the simulation for a selected scenario and region. Prices and quantities are variables, and the simulation will estimate new values for these in each time step of the simulation. The other fields are market parameters whose values are predetermined by the user. However, **DREAM** does allow the user to specify whether these market parameters change over the course of the simulation period. In the case of *Multiple Markets*, there are four possible ways in which the **Market** page can be filled out—

1. If the region will only generate technologies, it is not necessary to enter any market data on this page. In this case, R&D impacts will arise in other regions based on the model's ability to represent technology spillover between regions. (Case five in Table 1.)
2. For a production region, only the left side of the page should be completed. This region may or may not generate technologies. (Cases two, three, four, or eight in Table 1.)
3. For a consumption region, only the right side of the page should be completed. This region may or may not generate technologies. (Cases six or seven in Table 1.)
4. For a region that produces and consumes simultaneously, both sides of the page should be completed. This region may or may not generate technologies. (Case one in Table 1.)

The colored fields on this page (green for production and red for consumption) indicate the minimum essential data if production or consumption are to be included in the region specification.

In the case of a *Horizontal Multimarket* model, total production across all regions must equal total consumption across all regions, i.e., there must be an initial quantity equilibrium.

<u>Field</u>	<u>Description</u>
<i>Initial Price</i>	The base year observed equilibrium price for the specified region. If there are taxes or subsidies, DREAM calculates net producer and consumer prices.
<i>Transmission</i>	A price transmission elasticity represents the effects of transport and other transaction costs in the transmission of price changes among regions. Its value varies from 0 (no price change transmission) to 1 (perfect price change transmission). The default is 1.0.
<i>Quantity</i>	Specifies the quantity produced or consumed in the region in the base year.
<i>Elasticity</i>	Supply (production) and demand (consumption) price elasticities. Demand elasticities are negative.
<i>Growth Rate (percentage per year)</i>	Autonomous growth rate, i.e., changes in production or consumption resulting from factors other than research. On the production side, these changes could be explained by factors such as investments in irrigation, roads, or farmer education programs. On the consumption side, they could be related to population growth, changes in real wages, changes in consumer preferences, etc.
<i>Tax/Subsidy (percentage per year)</i>	Taxes and/or subsidies to production or consumption.

Within each of the *Elasticity*, *Growth Rate*, and *Tax/Subsidy* sections, there is a second field that allows changes to be made to the base year value of these parameters over time. **DREAM** takes the left-hand field as the base year value and, depending on the type of change specified, takes the right-hand field as either an annual increase or as the value of the parameter in the last year of the simulation (last year = base year + simulation period). The third option '*manual*' allows users to enter yearly values on the [Dynamics](#) page.

The price and quantity units used on the **Market** page are defined in the *Units* window, accessible by right-clicking in the *Regions* field in the **Scenario** page, and must correspond to the value units defined in the **Study** page. For instance, a value unit defined as US\$1,000 could correspond to a price unit of US\$ per ton, together with a quantity unit of 1,000 tons.

MARKET MODEL - 2 (Small Open Economy)

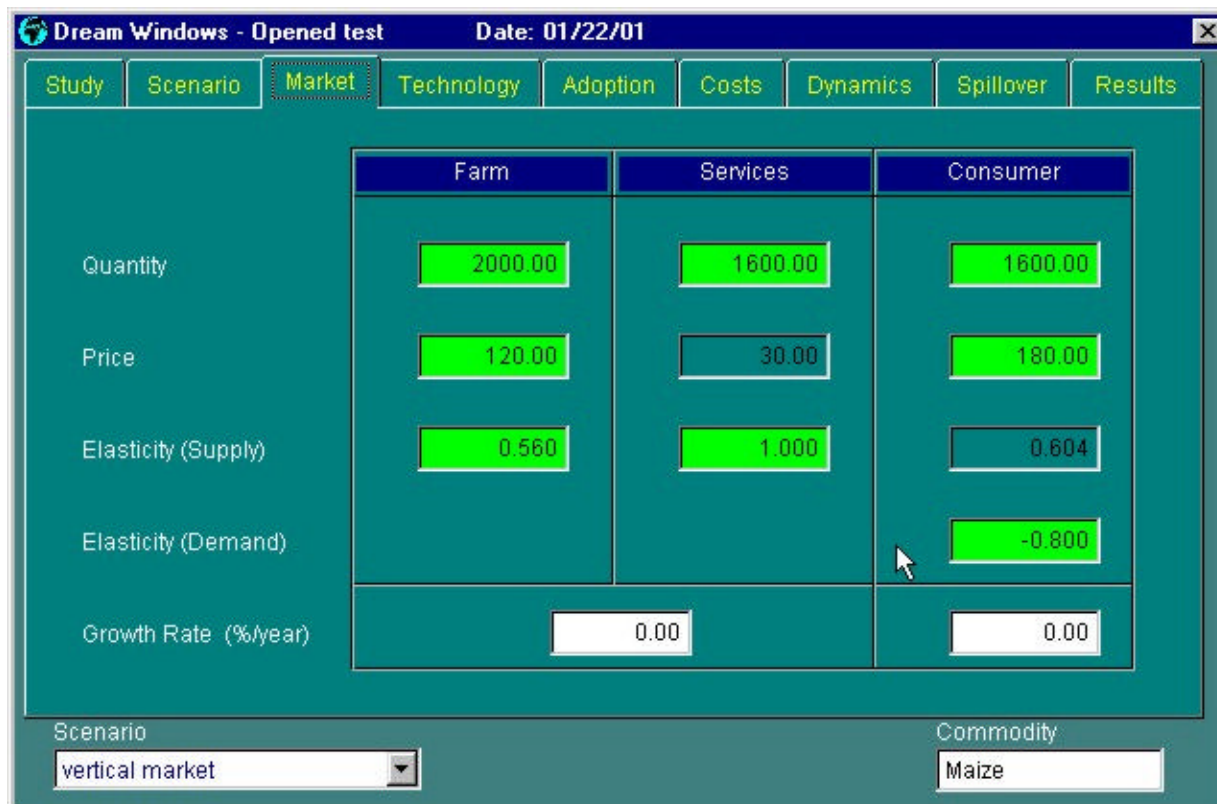
Purpose of the Page

This market model represents a small open economy for which price is determined exogenously. The price field is labeled as *world price*, but can be considered as any relevant price determined outside of the region of interest and that will remain unaffected by changes within the single market region. However, the user has the option to impose a fixed (also exogenous) change in price over time.

Field	Description
<i>World Price</i>	Specifies the initial (exogenous) price in the base year.
<i>Change in Price</i>	Expected exogenous change in world price (percentage per year). The change can be positive or negative. The default is zero.
<i>Quantity</i>	Quantities produced and consumed in the base year. Unlike the <i>Closed Market</i> and <i>Horizontal Multimarkets</i> cases, it is not necessary for production and consumption quantities to be in equilibrium.
<i>Elasticity</i>	Supply elasticity for production and demand elasticity for consumption. Demand elasticity (theoretically infinity) is not needed for technology-induced supply shift.
<i>Growth %/yr</i>	Exogenous growth rates in supply and demand. See Market Model - 1 .
<i>Tax/Subsidy</i>	Taxes on, or subsidies for, production and consumption.

Within each of the *Elasticity*, *Growth Rate*, and *Tax/Subsidy* sections, there is a second field that allows changes to be made to the base year value of these parameters over time. **DREAM** takes the left-hand field as the base year value and, depending on the type of change specified, takes the right-hand field as either an annual increase or as the value of the parameter in the last year of the simulation (last year = base year + simulation period). The third option "*manual*" allows users to enter yearly values on [Dynamics](#) page.

MARKET MODEL - 3 (Vertical Market - 3 Levels: Farm, Post-Harvest Services, and Consumer)



	Farm	Services	Consumer
Quantity	2000.00	1600.00	1600.00
Price	120.00	30.00	180.00
Elasticity (Supply)	0.560	1.000	0.604
Elasticity (Demand)			-0.800
Growth Rate (%/year)	0.00		0.00

Scenario: vertical market
Commodity: Maize

Purpose of the Page

This page is displayed when the *Vertical Market* model has been selected on the **Scenario** page. In this case, it is not possible to simultaneously represent multiple horizontal regions. The vertical model requires information for three levels in the production and marketing chain (these three levels are represented as three *Regions* in the **Scenario** page). By default, the three levels are defined as *Farm*, *Services* (or Post-harvest or value-added), and *Consumer*. The model assumes that inputs from *Farm* and *Services* are combined in fixed proportions to create the aggregate supply that satisfies a demand at the consumer level. Given this assumption, any autonomous growth of supply must apply equally to both *Farm* and *Services* sectors. It is not possible to include taxes or subsidies, nor to change the elasticity and growth parameters over time in this market model formulation.

Field

Description

Quantity

DREAM assumes that the user will provide quantity estimates at the farm level (Q_f) and at the consumer level (Q_c). For instance, 2,000 tons of wheat produced at the farm level and 1,600 tons of wheat flour demanded at the consumer level. At the post-harvest level the user can choose to define the quantity (Q_i) and its units either in terms of the input (2,000 tons of wheat) or of the output (1,600 tons of wheat flour) of the post-harvest process.

Price

DREAM assumes that prices at the farm level (P_f), e.g., US\$120 per ton of wheat, and at the consumer level (P_c), e.g., US\$180 per ton of flour, are available. The program computes the

implicit unit price of post-harvest services as $P_i = (P_c * Q_c - P_f * Q_f) / Q_i$ (e.g., US\$30 per ton of wheat or US\$60 per ton of flour).

Elasticity **DREAM** assumes that the user will provide supply elasticities for the farm and post-harvest sectors, and uses those to calculate aggregate supply elasticity at consumer level. The user must also provide the demand elasticity at the consumer level.

Growth Rate
(percentage per year) Allows the specification of supply (*Farm* and *Post-harvest*) and demand growth arising from factors other than R&D.

The *elasticity* and *growth rate* values cannot be specified as time variant. The *Region* navigation box is not available as all three regions needed to define this kind of market are already displayed on the screen.

MARKET MODEL - 4 (Closed Economy)

Dream Windows - Opened USAID Examples Date: 01/22/01

Study Scenario **Market** Technology Adoption Costs Dynamics Spillover Results

Initial Price 150.00 US\$/T

PRODUCTION

Quantity 260.00 1000 T

Elasticity

0.500 Increment
 End Value
 Manual

Growth Rate (%/year)

Increment
 End Value
 Manual

Tax/Subsidy (%/year)

Increment
 End Value
 Manual

CONSUMPTION

Quantity 260.00 1000 T

Elasticity

-0.500 Increment
 End Value
 Manual

Growth Rate (%/year)

Increment
 End Value
 Manual

Tax/Subsidy (%/year)

Increment
 End Value
 Manual

Scenario Closed economy Region Madagascar Commodity Wheat

Purpose of the Page

This market model represents a closed economy, which is a special case of horizontal multimarket with only one region. The fields are the same as [Market Model 1](#) (Horizontal multimarket). There is no price transmission field since only one region exists. In this formulation, the quantity produced *must* be equal to the quantity consumed.

TECHNOLOGY

R&D Impacts Supply Demand

R&D Time Lag: Years

Define potential R&D impacts on This page Dynamics page

Potential impacts if R&D successful and fully adopted

Fixed Change (%)			Cumulative Change (%/yr)		
Δ Costs%	Δ Yield%	Shift%	Δ Costs%	Δ Yield%	Shift%
<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="1.00"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text" value="0.00"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Kf % <input type="text" value="1.00"/>			Ka % /yr <input type="text"/>		

Probability of R&D Success %

Scenario: Region: Commodity:

Purpose of the Page

This page contains data related to R&D and its potential impacts (assuming the technologies are fully adopted). The **Adoption** data page will provide information on how to transform these potential impacts into *realized* impacts. This screen is fundamental to the entire evaluation process and its correct use requires a good grasp of the concepts, definitions, and limitations of the underlying economic analysis. The **DREAM** methodology (*Appendix 1*) expresses the potential impacts of research as being equivalent to a vertical shift (*Shift%*) in the supply curve (e.g., a decrease in the unit cost of production that can arise, for example, from lower input costs, or greater yields with the same level of inputs). Another option, having greater limitations in its application and interpretation, is a vertical shift in the demand curve. In both cases, the time required for the R&D must be specified.

For a typical analysis it may be sufficient to define a single fixed shift ($K_f\%$ with new technology) resulting from research, implying that without research there would be no shift ($K_f\%$ without new technology = 0). The program fills out the field $K_f\%$ automatically as a result of the computation $K_f = K_f^{with} - K_f^{without}$. If an estimate of the likely changes in unit costs of production without research is available, it can be entered directly into the appropriate field. As an illustration, consider a four-year research program to develop a new variety requiring a five-percent less inputs to obtain the same yield (if the research is successful). We enter four (years) in the *Time Lag* field and five (percent) in the *Shift%* (*with new technology*) field. Automatically, the field $K_f\%$ is updated with the same value (five percent). If we know that, after the four years over which the new technology will be developed, yields of existing varieties will probably be three percent less than in the base year (due to factors such as breakdown of pest resistance), we can enter negative three percent in the *Shift%* field corresponding to the line *without new technology*. **DREAM** will then compute the net shift, K_f , as $5 - (-3) = 8\%$. The screen also allows the user to provide more detailed

information about the sources of the R&D-induced supply shifts, in terms of the breakdown by cost changes or yield changes.

Fixed changes

The left side of the page is used for R&D impacts that are constant in time, i.e., once adopted the technology delivers the same benefit per ton or per hectare (*ceteris paribus*) every year. For instance, if a new technology reduces unit production costs by ten percent (relative to current technology), **DREAM** assumes that producers who adopt the technology will realize the same, fixed unit cost reduction in every year - until the producer introduces another, better technology.

Cumulative changes

The right side of the page allows the user to represent other types of technology that have time varying impacts. Here the R&D impact is allowed to change cumulatively every year, e.g., it is a $K/year$ or K_v (percentage per year). Examples include technologies that affect soil fertility in-situ. If soil is being eroded at a rate of eight millimeters per year without the new technology, and at three millimeters per year with the new technology, then knowing (or assuming) a relationship between soil depth and crop yield, we can estimate the likely productivity loss avoided with the new technology. If the eight millimeters per year soil erosion (*without new technology*) translates into a yield loss of 1.5 percent per year, and the three millimeters per year soil erosion (*with new technology*) represents a loss of 0.5 percent per year, we have an incremental R&D impact of $K_v = -0.5 - (-1.5) = 1.0\%$ per year, relative to the old technology.

Potential R&D impacts can also be entered in the [Dynamics](#) page if the yearly k 's are known. However, the shift type (supply or demand) must still be specified on the **Technology** page.

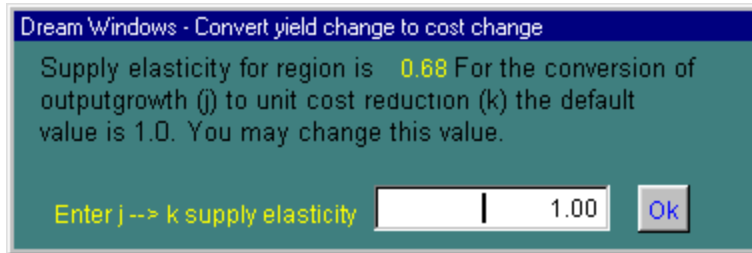
Finally, it is also possible to leave this page blank if the region is not undertaking research, remembering it could still be possible to obtain production-related impact in the region as a consequence of technology spill-in. In Table 1, region types 3, 4, 6, 7, and optionally 8, might not have technology data defined.

<u>Field</u>	<u>Description</u>
<i>Shift Type</i>	Defines an R&D-induced shift in supply (by default) or in demand.
<i>Time Lag</i>	Time needed to complete the research (in years).
<i>Change in Costs</i>	Optional. Percentage change in cost of production (per hectare or per animal – holding output constant) if the R&D is successful and the technology is fully adopted (can be positive or negative).
<i>Change in Yield</i>	Percentage change in the yield (output per hectare or per animal) if the R&D is successful and the technology is fully adopted (usually positive).
<i>Shift(K)</i>	The net R&D impact from changes in production costs and yield if the R&D is successful, expressed as a net percentage decrease in the cost of producing one unit of output. Users may enter the shift value directly into this field, or enter the component cost and yield changes separately. In the latter case, DREAM calculates the net shift according the following formula: $shift = change\ in\ yield / elasticity\ of\ supply$ (see $j \rightarrow k$ below) – $change\ in\ cost / (1 + change\ in\ yield / 100)$.
<i>Probability of Success</i>	The probability that the R&D will be successful.

$j \rightarrow k$

Displays a dialog box to specify the elasticity value used to express a technology-induced, horizontal supply-curve shift (e.g., an increase in production as a consequence of yield improvement) as an equivalent downward vertical shift (reduction in the unit cost of production).

Related Windows or Dialog Boxes



The $j \rightarrow k$ dialog box allows the user to specify the appropriate supply elasticity value to be used when converting horizontal supply-curve shifts into equivalent vertical supply shifts. As recommended by Alston et al. (1995), the default value here is 1.0.

ADOPTION

The screenshot displays the 'ADOPTION' tab within a software window titled 'Dream Windows - Opened LAC -A1' with a date of '01/18/01'. The interface is divided into several sections:

- Adoption Form:** Radio buttons for 'Linear' and 'Sigmoid', with 'Sigmoid' selected.
- Disadoption:** Radio buttons for 'No' and 'Yes', with 'No' selected.
- Adoption Lag:** A green input field containing '5' followed by 'Years'.
- Max. Adoption Level:** A green input field containing '100.0' followed by '%'. A mouse cursor is pointing at this field.
- Years at Max. Level:** A grey input field containing '99' followed by 'Years'.
- Years to Abandon:** A grey input field containing '0' followed by 'Years'.

Below the settings is a graph with 'Adoption Level' on the y-axis (ranging from 0 to 100) and 'Years' on the x-axis. A sigmoid curve starts at (0,0) and levels off at 100% adoption around year 5. Dashed lines indicate the point (5, 100) on the curve.

At the bottom of the window, there are three dropdown menus:

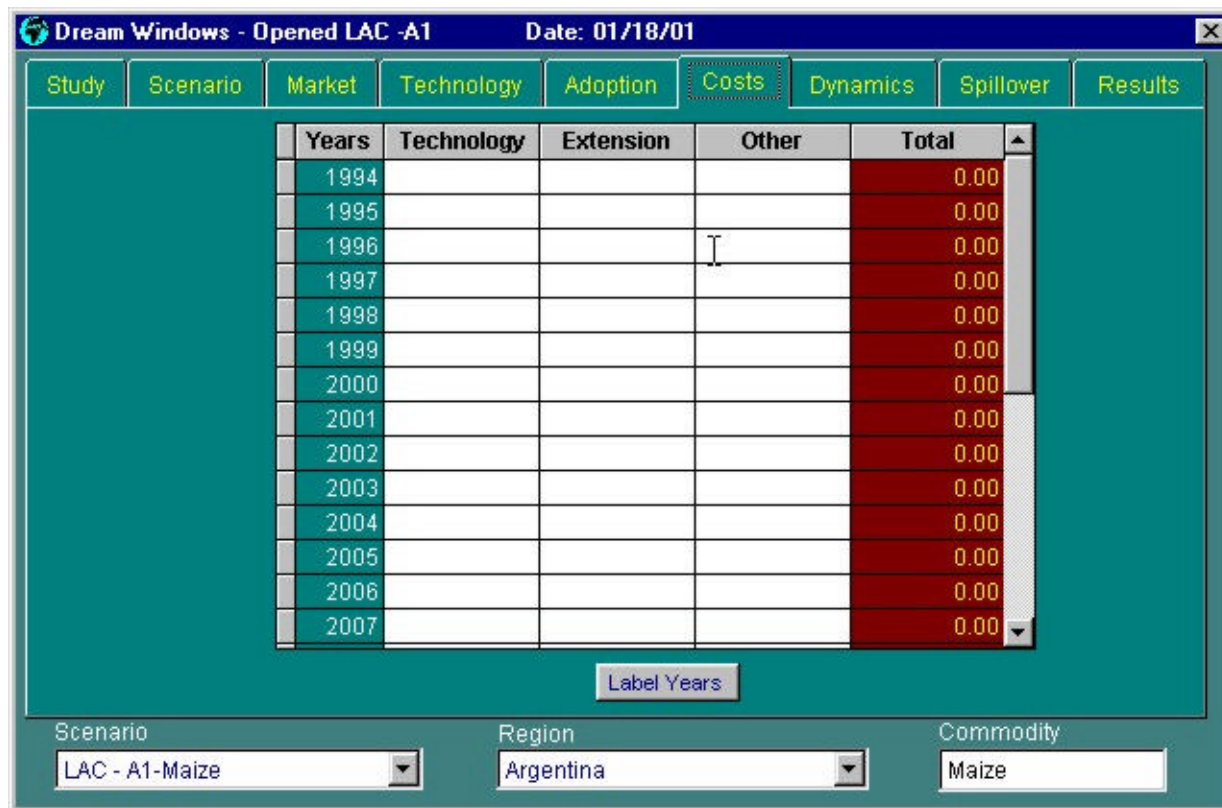
- Scenario: LAC - A1-Maize
- Region: Argentina
- Commodity: Maize

Purpose of the Page

This page specifies the time dynamics and functional form of the adoption curve. This information is used to convert the potential impact of new technology defined in the R&D page into the actual impact that can only be realized by technology adoption. This page is completed only if the selected region produces the commodity being analyzed and the new technology will be adopted in that region. The technology may be local ----- as defined on the [Technology](#) page for the same region, or may come from another region (as prescribed up in the [Spillover](#) page).

<u>Field</u>	<u>Description</u>
<i>Adoption Form</i>	Select the function used to describe technology adoption. There are two possible functional forms: linear and sigmoid.
<i>Adoption Lag</i>	Specify the time lag between the first availability of the new technology and the point at which the maximum adoption level is expected to be reached.
<i>Maximum Adoption Level</i>	The maximum level (percentage) of adoption. Theoretically, this is defined as a percentage of production. In practice, however, the proportion of cultivated area or of producers is often used as a proxy measure.
<i>Disadoption</i>	Specify whether or not the analysis will assume technology disadoption.
<i>Years at Maximum Level</i>	This is the estimated period over which the technology will be adopted at the maximum level (in years). This period is arbitrarily set to 99 years if no disadoption is specified.
<i>Years to Abandon</i>	This is the time, in years, for disadoption to occur (if specified). The default value is zero (no disadoption).

COSTS



Dream Windows - Opened LAC -A1 Date: 01/18/01

Study Scenario Market Technology Adoption **Costs** Dynamics Spillover Results

Years	Technology	Extension	Other	Total
1994				0.00
1995				0.00
1996				0.00
1997				0.00
1998				0.00
1999				0.00
2000				0.00
2001				0.00
2002				0.00
2003				0.00
2004				0.00
2005				0.00
2006				0.00
2007				0.00

Label Years

Scenario: LAC - A1-Maize Region: Argentina Commodity: Maize

Purpose of the Page

This page specifies the costs associated with the generation, development, and dissemination of the new technology for the selected region. The intention here is to capture all those costs related to the generation and supply of the technology and making it available to farmers. Not included are producer's private costs of technology adoption and use, since these effects are included in the shift definition on the **Technology** page. Cost units used must be those defined on the **Study** page, e.g., US\$1,000.

Field Description

Year The year label. This field is filled automatically by clicking on the *Label Years* button.

R&D Annual R&D costs for the new technology in the selected region.

Extension Annual costs associated with the extension and dissemination of the new technology in the selected region.

Other Any other expenses associated with the generation, transfer, and dissemination of the new technology in the selected region.

Total Sum of total costs (*R&D*, *Extension*, *Other*). Filled automatically.

DYNAMICS



Years	Production			Consumption			k (%)
	Elasticity	Growth Rate	Tax/Subsidy	Elasticity	Growth Rate	Tax/Subsidy	
1994	1.00	2.17	0.00	-0.50	2.17	0.00	1.00
1995	1.00	2.15	0.00	-0.50	2.15	0.00	1.00
1996	1.00	2.13	0.00	-0.50	2.13	0.00	1.00
1997	1.00	2.11	0.00	-0.50	2.11	0.00	1.00
1998	1.00	2.10	0.00	-0.50	2.10	0.00	1.00
1999	1.00	2.07	0.00	-0.50	2.07	0.00	1.00
2000	1.00	2.04	0.00	-0.50	2.04	0.00	1.00
2001	1.00	2.02	0.00	-0.50	2.02	0.00	1.00
2002	1.00	2.00	0.00	-0.50	2.00	0.00	1.00
2003	1.00	1.97	0.00	-0.50	1.97	0.00	1.00
2004	1.00	1.94	0.00	-0.50	1.94	0.00	1.00
2005	1.00	1.91	0.00	-0.50	1.91	0.00	1.00
2006	1.00	1.88	0.00	-0.50	1.88	0.00	1.00
2007	1.00	1.84	0.00	-0.50	1.84	0.00	1.00

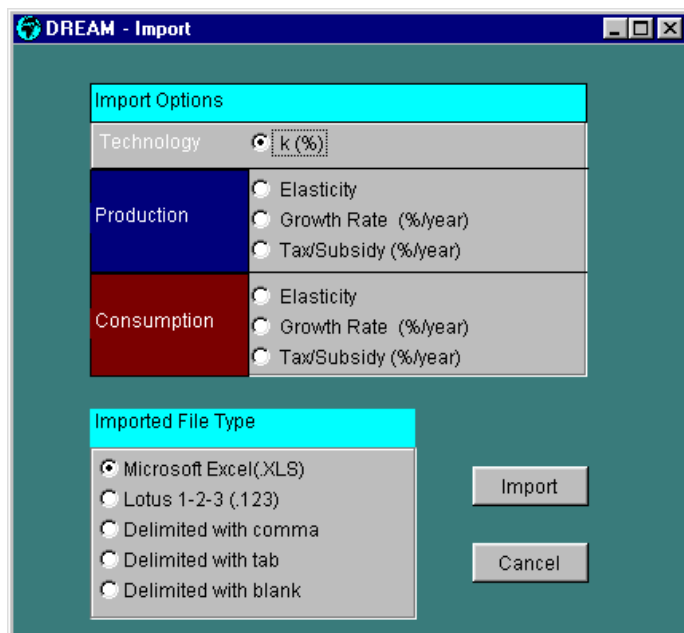
Scenario: LAC - A1-Maize Region: Argentina Commodity: Maize

Purpose of the Page

For the selected region, this page displays the year-by-year values of those **DREAM** market and technology parameters that can be defined as time-varying. The nature of the time variability has already been specified by the user in the **Market** or **Technology** pages. The data page shows the computer-generated **DREAM** parameter values on a year-by-year basis (For *Increment* and *End value* options on **Market** page). Most often the **Dynamics** page is used simply to review user specific input values. In addition, users can edit or enter the annual values further, if necessary, in the **Dynamics** page. To save edits to the edited values, the “*manual*” option on **Market** page or “*Enter potential R&D impacts on Dynamics page*” in this page must be selected. Otherwise, if any changes are subsequently made in the **Market** or **Technology** pages, the *Dynamic* data is automatically regenerated and the imported/edited values are lost.

<u>Field</u>	<u>Description</u>
<i>Elasticities</i>	Elasticity values for each year of the simulation period (for production and consumption).
<i>Growth</i>	Growth values for each year of the simulation period (for production and consumption).
<i>Tax/Subsidy</i>	Tax/subsidy rates for each year of the simulation period (for production and consumption).
<i>K (%)</i>	Technology-induced supply shifts expressed as a net percentage decrease in unit production costs.
<i>Import</i>	Button to activate the import of dynamic data. See a description of this feature below.

Related Windows



In some specific cases, such as ex post analyses, users may wish to enter year specific values of model parameters. This can be a very tedious process for many regions, simulation years and model parameters. To facilitate data entry in such cases, it is possible to import suitably formatted data. Clicking the *Import* button will pop up the *IMPORT* window as shown. This window allows users to import dynamic data (i.e., technology shifts, *k*'s, elasticities, growth rates, taxes/subsidies) from other applications.²

Data to be imported can be held in ASCII or spreadsheet formats. Examples of two such formats are shown in the following figures: Microsoft Excel file and comma-delimited text file.

DREAM handles import data in the following

ways:

1. Any line (or row in spreadsheet) started with “!” is a comment line, and **DREAM** will ignore it.
2. **DREAM** expects field headers before the data, though the header titles are not imported.
3. The first column should contain region names exactly as defined in the **Scenario** page. The second column contains year numbers, the third the specified parameter value (e.g., elasticity, growth rate, or tax/subsidy). In the case of imported *k*'s, two columns of data must be provided. The third column should contain the absolute change in production costs – holding output constant, and the fourth column is the yield increase in percentage due to technology or resources changes. **DREAM** calculates the technology shift, *k*, as follows: $k = \text{change in yield} / \text{elasticity of supply (j} \rightarrow \text{k)} - 100 * (\text{change in cost}/(\text{commodity price}) * (1 + \text{change in yield}/100))$. Cost reductions should be defined as negative.
4. The data series to be imported should commence from the same base year specified in **Scenario** page (even if values are zero for the first few years). If the number of years of imported data is less than the simulation period, each year up to the end of the simulation period takes the value of the last year in the input data. **DREAM** will truncate the data if the imported years of data are greater than the simulation period.
5. For ASCII files, character string values (region names) must be embedded in quotation marks.
6. To ensure imported values are not overwritten when a new **DREAM** simulation run is made (the default procedure), the “*manual*” option on **Market** page or “*Enter potential R&D impacts on Dynamics page*” on **Technology** page must be selected. Otherwise, **DREAM** will automatically regenerate dynamic data during the scenario run and overwrite the imported values.

² The technology importing function was originally used to import the *k* values derived from the **DSSAT** (Decision Support System for Agrotechnology Transfer) suite of crop simulation models.

import_excel.xls

	A	B	C	D
1	! This is a sample data file in Excel format.			
2	! Any line beginning with "!" is a comment line.			
3	Region	Year	Delt Cost(price unit)	Delt Yield(%)
4	Kenya	2000	0	0
5	Kenya	2001	0	0
6	Kenya	2002	0	0
7	Kenya	2003	0	0
8	Kenya	2004	-10	3
9	Kenya	2005	-20	2
10	Kenya	2006	-30	2
11	Kenya	2007	-40	2
12	Kenya	2008	-70	2
13	Kenya	2009	0	0
14	Kenya	2010	0	0
15	Kenya	2011	0	0
16	Kenya	2012	0	0
17	Kenya	2013	0	0
18	Tanzania	2000	0	0
19	Tanzania	2001	0	0
20	Tanzania	2002	0	4
21	Tanzania	2003	0	4
22	Tanzania	2004	0	4

Sheet1 Sheet2 Sheel

D:\DREAM\dream\Database\import_csv.txt *

```

! This is a sample data file in
! comma-delimited format.,,,
! Any line beginning with "!" is
! a comment line.,,,
"Region","Year","Delt Cost(price unit)","Delt
"Kenya",2000,0,0
"Kenya",2001,0,0
"Kenya",2002,0,0
"Kenya",2003,0,0
"Kenya",2004,-10,3
"Kenya",2005,-20,2
"Kenya",2006,-30,2
"Kenya",2007,-40,2
"Kenya",2008,-70,2
"Kenya",2009,0,0
"Kenya",2010,0,0
"Kenya",2011,0,0
"Kenya",2012,0,0
"Kenya",2013,0,0
"Tanzania",2000,0,0
"Tanzania",2001,0,0
"Tanzania",2002,0,4
"Tanzania",2003,0,4
"Tanzania",2004,0,4
"Tanzania",2005,0,4
"Tanzania",2006,0,4

```

SPILLOVER

From	To	Value	Lag
Argentina	Argentina	1.000	0
Argentina	Bolivia	0.000	0
Argentina	Brasil	0.000	0
Argentina	Chile	0.000	0
Argentina	Colombia	0.000	0
Argentina	Costa Rica	0.000	0
Argentina	Ecuador	0.000	0
Argentina	El Salvador	0.000	0
Argentina	Guatemala	0.000	0
Argentina	Haiti	0.000	0
Argentina	Honduras	0.000	0
Argentina	Dominican Republic	0.000	0

Purpose of the Page

This page contains information governing the conditions under which technology spillover might occur among regions. By default, **DREAM** assumes that technology does not spillout from innovating regions (those for which a technology shift is defined on the **Technology** page). There is only one spillover page per scenario. In order to include spillover, the user must specify whether the technologies being transferred should be treated as substitutes for local technologies (the “with spillover” default) or are complementary to local technologies. For each transfer possibility (between each pair of regions), a transfer coefficient (*Value*) must be specified (see [Appendix 1](#)) and, optionally, the time lag (*Lag*) necessary to complete the technology transfer (and perhaps adaptation) between the specified pair of regions.

Field Description

Spillover Specify the inclusion (or, by default, exclusion) of technology spillover as part of the Scenario.

Subst. or Compl. Specify whether the technologies entering a region are treated as substitutes or complements. In the case of substitutes, the technology with the largest cost-reducing potential (maximum *K*) is selected. In the case of complements, it is assumed that the technologies can be used conjunctively and the incoming *Ks* are added. By default, the technologies are defined as substitutes.

From Region where the technology originates (spillout region).

<i>To</i>	Region receiving the technology transfer (spillin region).
<i>Value (coefficient)</i>	The spillover coefficient, \mathbf{z}_{ij} , the proportion of the unit cost reduction impact in region i , K_i , which can be achieved in region j . Thus, $K_j = \mathbf{z}_{ij}K_i$
<i>Lag</i>	Time, in years, for the technology to be transferred from the source region to the receiving (spillin) region.
<i>Delete</i>	Delete spillover matrix, and return to the default unit spillover matrix.
<i>Spill</i>	Create the spillover matrix for the scenario. Before running a scenario for the first time (or if the number of regions is altered), this button must be clicked to (re)generate a spillover matrix.

Even when technology spillover has not been selected, a dummy spillover matrix is generated since the matrix is an integral part of a **DREAM** analysis. The default spillover matrix is a unit matrix, i.e., it contains zeros everywhere except for the leading diagonal, which has the value 1.0 (in spillover terms, this matrix allows a technology to be adopted only in the region for which it was originally defined).

RESULTS

Report Type

Output 1: Region by Year (1 of 2) Preview Printer

Years	Region	Benefits (1000US\$)				Cost	B - C
		Producer	Consumer	Government	Total		
1995	Argentina	-120.5	65.0	0.0	-55.5	0.00	-55.50
1996	Argentina	-241.6	131.2	0.0	-110.4	0.00	-110.40
1997	Argentina	-363.5	198.5	0.0	-165.0	0.00	-165.00
1998	Argentina	-486.1	267.0	0.0	-219.1	0.00	-219.10
1999	Argentina	-609.4	336.6	0.0	-272.8	0.00	-272.80
2000	Argentina	-611.3	339.4	0.0	-271.9	0.00	-271.90
2001	Argentina	-613.0	342.3	0.0	-270.7	0.00	-270.70
2002	Argentina	-614.8	345.0	0.0	-269.8	0.00	-269.80
2003	Argentina	-616.8	347.8	0.0	-268.8	0.00	-268.80
2004	Argentina	-618.3	350.6	0.0	-267.7	0.00	-267.70
2005	Argentina	-620.0	353.3	0.0	-266.7	0.00	-266.70
2006	Argentina	-621.7	355.9	0.0	-265.8	0.00	-265.80
SCENARIO TOTAL		246824.20	325336.46	0.00	572160.66	0.00	0.00

Scenario: LAC - A1-Maize Region: Argentina Commodity: Maize

This page allows the user to generate and access **DREAM** simulation, and to display or print them. There are two main report groups—one for the input data (four reports) and another one for the results (five reports). In order to access a report, a scenario must first be *Run* and the results specified in TABLE output format.

<u>Field</u>	<u>Description</u>
--------------	--------------------

<i>Report Type</i>	Selects one of the nine types of report.
--------------------	------------------------------------------

<i>Generate</i>	Starts generating a report.
-----------------	-----------------------------

<i>Preview/Printer</i>	Defines where the report will be displayed. If <i>Preview</i> is selected, a report will be displayed on the screen and a control bar will appear, allowing the user to move between pages, go to the beginning or to the end, print, and exit the Preview mode. If <i>Printer</i> is selected, the program will send the report directly to the printer after displaying the printer selection window to allow the user to specify the printing range, and the number of copies.
------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<i>Run</i>	Generates a new set of results by running a simulation for the currently selected scenario (the actions and options generated are the same as for the <i>Run</i> button on the Scenario page. See Output Option).
------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<i>Rank</i>	Rank the simulation results. It is only for <i>Table</i> output.
-------------	------------------------------------------------------------------

<i>Compare</i>	Compare two scenarios. It is only for <i>Table</i> output.
----------------	------------------------------------------------------------

There are two scenario output formats. In the *Table* format (default) the simulation results are added to a database containing the results of all scenarios for all studies. Users can access any results stored in the database using the scenario drop-down box in the **Results** page. Results can be reviewed on-screen or sent to the printer. Every time a scenario simulation is made with output specified as *Table*, the new results replace (overwrite) the existing results of the current scenario held in the results database. The alternative output format is a single *ASCII* (text) file, which can be reviewed on-screen, named, and saved permanently on the hard disk. This format is useful for examining the detailed scenario inputs and results, and for passing those data to other packages, e.g., spreadsheet or word processor.

Related Windows

Rank

Scenario	SCENARIO TOTAL	Producer	Consumer	Government	Total	Cost	IRR
2 Regions - spill	2 Regions - spill	30729.4	30600.4	0.0	61329.800	0.00	0.00
2 regions - no spill	2 regions - no spill	13020.1	12965.0	0.0	25985.100	0.00	0.00
2 Regions - transmis	2 Regions - transmis	12849.7	12789.8	0.0	25639.500	0.00	0.00
1 variable k	1 variable k	9868.8	9840.7	0.0	19709.500	0.00	0.00

This page allows the results from one or more scenarios to be ranked at different levels of aggregation: scenario, region group, or region, according to the values of different comparison criteria: total, consumer, or producer benefits, government revenues, costs, or IRR (Internal Rate of Return).

Field	Description
<i>Scenario - source</i>	This field shows all the scenarios in the current study. Double-clicking a scenario selects the scenario for ranking. The scenario name then appears in the right “ <i>Scenario – Selected</i> ” list.
<i>Scenario - Selected</i>	Scenarios selected for ranking. Selected scenarios must already have been <i>Run</i> using the <i>Table</i> output format. Double-clicking a scenario deselects the scenario from the ranking list.
<i>Aggregation Level</i>	Allows selection of one of three aggregation levels for which the results will be compared: scenarios, region groups, and regions.
<i>Print</i>	Preview the current ranking report on the screen. A control bar will appear, allowing the

user to move between pages, go to the beginning or to the end, print, and exit the Preview mode.

OK Close the *Rank* window.

Scenario Scenario names to be ranked.

ScenarioTotal/Group Total/Region Total Shows scenario or region group or region names depending which aggregation level has been selected.

Producer Producer benefits. Clicking the field header will list the results in descending order of producer benefits.

Consumer Consumer benefits. Clicking the field header will list the results in descending order of consumer benefits.

Government Government revenues. Clicking the field header will list the results in descending order of government revenues.

Total Total benefits. Clicking the field header will list the results in descending order of total benefits.

Cost Cost of the new technology. Clicking the field header will list the results in descending order of cost.

IRR Internal Rate of Return. Clicking the field header will list the results in descending order of IRR.

Comparison

SCENARIO TOTAL	Producer	Percent	Consumer	Percent	Government	Percent	Total	Percent	Cost	Percent
2 regions - no spill	17709	136.0	17635	136.0	0	0.0	35345	136.0	0	0.0

This option allows any two scenarios to be compared with each other at scenario, region group, or region levels. It is designed mainly for sensitivity analysis. For the scenario to be compared at region group and region levels, the group names and region names must be the same. In such cases it is helpful to use the “*copy scenario*” option when creating new scenarios that will later be compared.

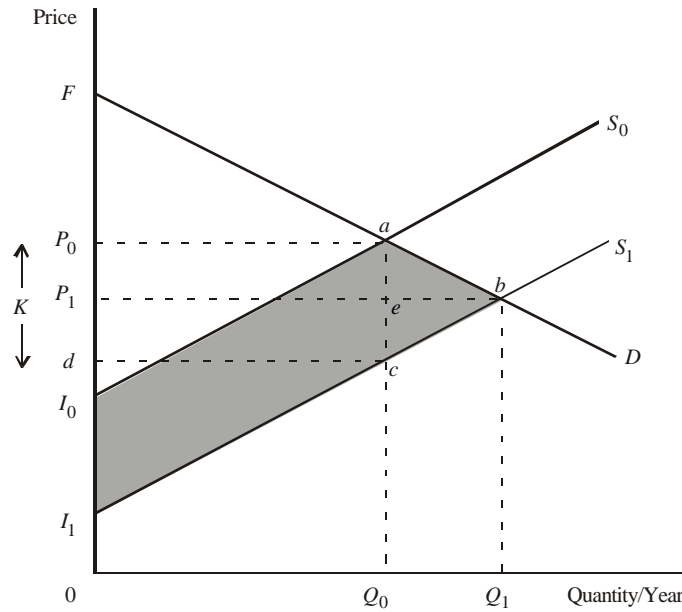
<u>Field</u>	<u>Description</u>
<i>Scenario - Source</i>	This field shows all the scenarios in the current study. Double-clicking a scenario selects the scenario for comparison. The scenario name then appears in the right “ <i>Scenario – Selected</i> ” list.
<i>Scenario - Selected</i>	Scenarios selected for comparison. Only two scenarios can be selected. The first scenario is the base scenario. Both scenarios must have been <i>Run</i> using <i>Table</i> output format for the comparison to function correctly. Double-clicking a scenario deselects the scenario from the comparison list.
<i>Aggregation Level</i>	Defines the three available aggregation levels: scenarios, region groups, regions.
<i>Print</i>	Preview the current comparison report on the screen. A control bar will appear, allowing the user to move between pages, go to the beginning or to the end, print, and exit the Preview mode..
<i>OK</i>	Close the <i>Comparison</i> window.
<i>ScenarioTotal/Group Total/Region Total</i>	Shows scenario, region group or region names from the base scenario, depending which aggregation level is selected.
<i>Producer</i>	Producer benefit differences. Clicking the field header will list the results in descending order of producer benefits.
<i>Percent</i>	Relative benefits/cost expressed in percentage.
<i>Consumer</i>	Consumer benefit difference. Clicking the field header will list the results in descending order of consumer benefits.
<i>Government</i>	Government revenue difference. Clicking the field header will list the results in descending order of government revenues.
<i>Total</i>	Total benefit difference. Clicking the field header will list the results in descending order of total benefits.
<i>Cost</i>	Cost difference of the new technology. Clicking the field header will list the results in descending order of cost.

APPENDIX 1 DREAM Model

I. GENERAL CONCEPT

An economic approach to evaluating R&D begins with the basic, commodity market model of research benefits depicted in Figure 1: S_0 represents the supply function before a research-induced technical change, and D_0 represents the demand function. The initial price and quantity are P_0 and Q_0 . Suppose research generates yield increasing or input saving technologies. These effects can be expressed as a per unit reduction in production costs, K , that are modeled as a parallel shift down in the supply function to S_1 . This research-induced supply shift leads to an increase in production and consumption to Q_1 ($\Delta Q = Q_1 - Q_0$), and the market price falls to P_1 (by $\Delta P = P_0 - P_1$). Consumers are better off because R&D enables them to consume more of the commodity at a lower price.

Figure 1: *The Basic Supply-and-Demand Model of Research Benefits*

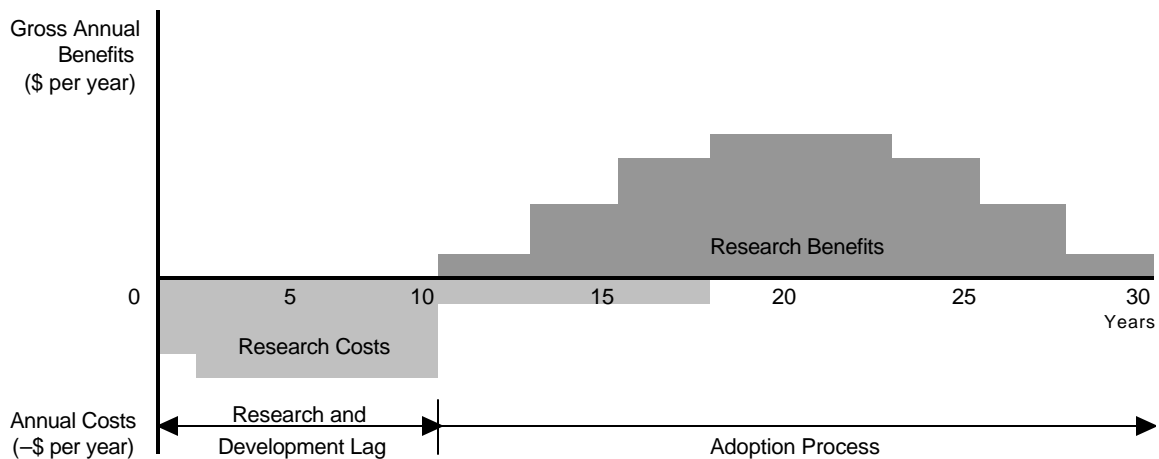


Although they receive a lower price per unit, producers who adopt the new technology are better off, too, because their unit costs have fallen by an amount, K per unit, that is more than the fall in price. The consumer surplus measure of the consumer benefit is equal to area P_0abP_1 , i.e. rectangle P_0aeP_1 ($=Q_0 \times \Delta P$) plus triangle abe . The producer surplus measure of the

producer gain is equal to area P_1bcd in Figure 1, i.e. rectangle $P_1ecd (=Q_0 \times [K - \Delta P])$ plus triangle bce . Total benefits are obtained as the sum of producer and consumer benefits. As an approximation, the cost-saving per unit multiplied by the initial quantity, KH_0 , is often used. Thus the size of the market, as indexed by the initial quantity Q_0 , as well as the size of the research-induced savings in the per unit cost of production, K , are critical factors in estimating the economic benefits from R&D. Better estimates of K mean better estimates of the benefits from research, and a better basis on which to allocate scarce research resources.

Figure 1 is the basic static model for research evaluation. However, evaluations of the economic effects of research involve procedures to account for the timing of streams of benefits and costs, since there may be lengthy lag times between the initial investment in research, the eventual adoption of research results, and the flow of research benefits. Figure 2 represents schematically the timing of flows of benefits and costs from a successful investment in developing a new technology.³ The vertical axis represents the *flow of benefits and costs* in a particular year and the horizontal axis represents years after the commencement of the R&D investment.

Figure 2: Time Profiles of Research Costs and Benefits



Initially, R&D projects involve expenditure without benefits so that, during the *research lag* period (say 3-10 years), only R&D costs (negative benefits) are considered. After the initial

³ Many new technologies are not successful in the sense that they are never developed for commercial use or adopted in the field. The figure refers to a new technology that is successful, and adopted.

research lag there may be a further delay, a *development lag* of several years, involving field trials for testing, certification and approval of the new technology or new variety. Even when a commercial product is available, there are further lags before the maximum adoption of the new technology is achieved. The *adoption lag* may involve several years. Eventually, as shown in Figure 2, the annual flow of net benefits from the adoption of the new technology becomes positive (at least, for a profitable investment this is true). In most cases the flow of benefits will eventually decline as the new technology is progressively abandoned when it becomes obsolete (e.g., as newer and better technologies evolve) or depreciates (e.g., as pests evolve), or becomes uneconomic for some other reason. A complete evaluation of a particular research investment must therefore take account of the dynamic relationships between investments in research that lead (after some lags) to a stream of future benefits as shown in Figure 2.

II. DREAM APPROACH

The **DREAM** approach is based upon the economic surplus method. **DREAM** is developed assuming the following conditions:

- multiple regions, i
- producing a homogeneous product
- with linear supply and demand in each region
- with exponential (parallel) exogenous growth of linear supply and demand
- with a parallel research-induced supply shift in one region (or multiple regions)
- with a consequent parallel research-induced supply shift in other regions
- with a range of market-distorting policies
- with zero transport costs (at least initially)
- with a research lag followed by a linear adoption curve up to a maximum
- with an eventual linear decline

This example for one commodity could be duplicated across a range of commodities (or research programs for a single commodity or several commodities) in a priority-setting study. It considers only the benefit side of the cost-benefit equation. Additional work would be needed, measuring the present value of the costs of achieving the supply shift, to complete the analysis. The model, developed in detail below, is the conceptual basis for the *Dream*[®] computer program that has been developed for research priority setting and evaluation

General Form of Supply and Demand

For region i in year t , linear supply-and-demand equations for a particular commodity (subscript suppressed) are specified as

$$\text{Supply: } Q_{i,t} = \mathbf{a}_{it} + \mathbf{b}_i PP_{i,t} \quad (1a)$$

$$\text{Demand: } C_{i,t} = \mathbf{g}_{it} + \mathbf{d}_i PC_{i,t} \quad (1b)$$

The first subscript, i , refers to a region, and the second subscript, t , refers to years from the initial starting point of the evaluation. The slopes are assumed to be constant for each region for all time periods. The intercepts may grow over time to reflect underlying growth in supply or demand due to factors other than research (i.e., growth in productivity or income). All of the variables are expressed in real terms so that any growth is real growth. One important implication of this is that the discount rate used in subsequent analysis to compare costs and benefits of research over time must be a real rate.

Initial Parameterization

The parameters of the supply-and-demand equations are defined by beginning with initial ($t=0$) values of

- quantity consumed in each region – $C_{i,0}$
- quantity produced in each region – $Q_{i,0}$
- producer price in each region – $PP_{i,0}$
- consumer price in each region – $PC_{i,0}$
- elasticity of supply in each region - $\mathbf{e}_{i,0}$
- elasticity of demand in each region - $\mathbf{h}_{i,0}$ (<0)

In many cases, the initial values of elasticities would be assumed to be equal among regions (a convenient, but not necessary, assumption). These initial values are sufficient to allow us to compute the slope and intercept of supply and demand in each region for the initial year:

$$\mathbf{b}_{i0} = \mathbf{e}_{i0} Q_{i,0} / PP_{i,0} \quad (2a)$$

$$\mathbf{a}_{i0} = (1 - \mathbf{e}_{i0})Q_{i,0} \quad (2b)$$

$$\mathbf{d}_{i0} = \mathbf{h}_{i0}C_{i,0} / PC_{i,0} \quad (2c)$$

$$\mathbf{g}_{i0} = (1 - \mathbf{h}_{i0})C_{i,0} \quad (2d)$$

Exogenous Growth in Supply and Demand

We incorporate average exponential growth rates to reflect growth in demand (due to growth in population and income) and supply (due to growth in productivity or an increase in area cropped) that is expected to occur regardless of whether the research program of interest is undertaken.

$$\mathbf{a}_{it} = \mathbf{a}_{it-1} + \mathbf{p}_i^Q Q_{i,t} \text{ for } t > 0 \quad (3a)$$

$$\mathbf{g}_{it} = \mathbf{g}_{it-1} + \mathbf{p}_i^C C_{i,t} \text{ for } t > 0 \quad (3b)$$

where

\mathbf{p}_i^C = the growth rate of demand (e.g., population growth rate + income elasticity
× income growth rate)

\mathbf{p}_i^Q = is the growth rate of supply (e.g., area growth rate + yield growth rate not
attributable to research)

Now we have sufficient information to parameterize the supply-and-demand equations for each region in each year under the no-research scenario.

Research-Induced Supply Shifts

Local effect of research: Let region i undertake a program of research with

- probability of success p_i , which, if the research is successful and the results are fully adopted, will yield
- a cost saving per unit of output equal to c_i percent of the initial price, $PP_{i,0}$ in region i , while
- a ceiling adoption rate of A_i^{MAX} percent holds in region i

Figure 3: *Trapezoidal Adoption Profile*

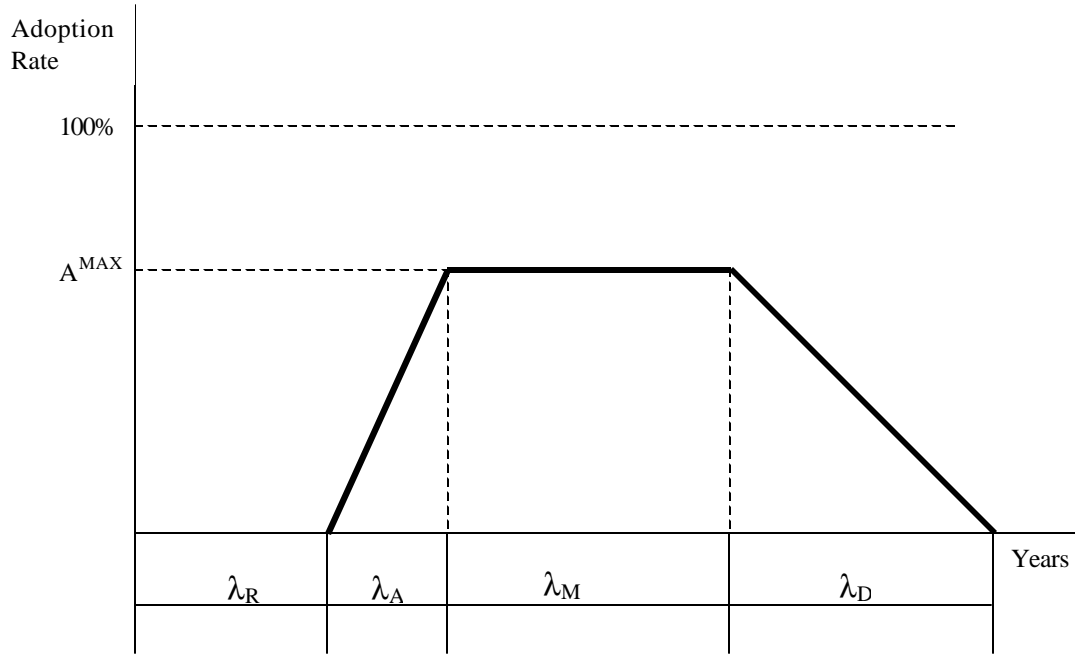
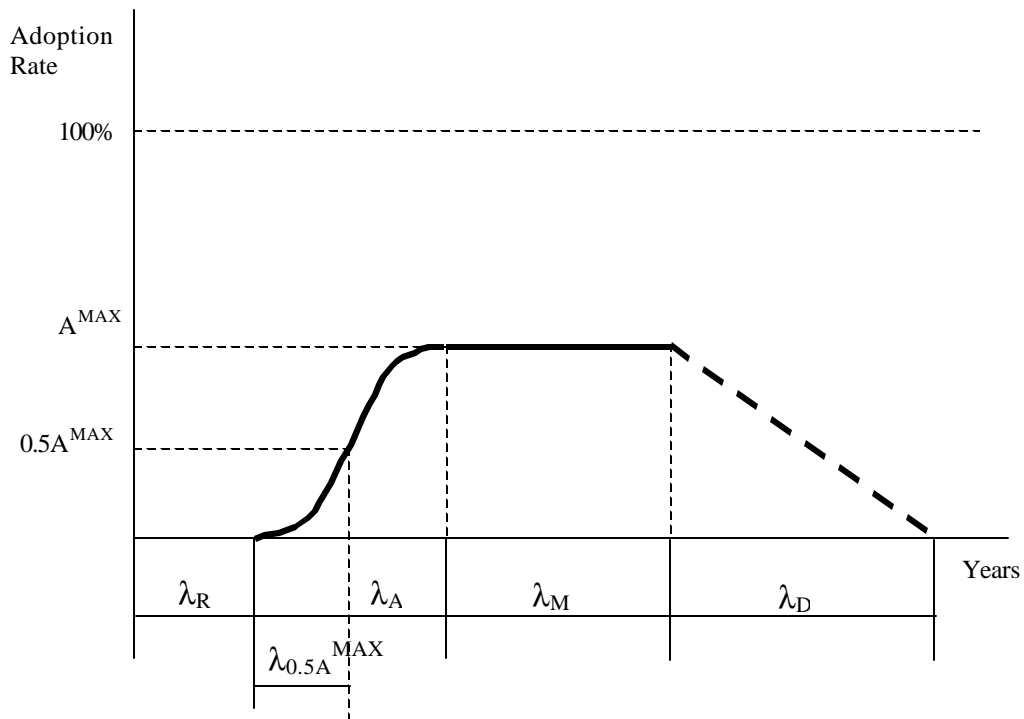


Figure 4: *Logistic Adoption Profile*



Then it is *anticipated* that the supply function in region i will shift *down* (in the price direction), eventually, by an *amount per unit* equal to

$$k_i^{MAX} = p_i c_i A_i^{MAX} P P_{i,0} \geq 0 \quad (4)$$

The *actual* supply shift in any particular year is some fraction of the eventual *maximum* supply shift, k_i^{MAX} , defined above. In order to define the actual supply shift, we can combine the maximum supply shift with other information about the shape of the time path of $k_{i,t}$ based on data about adoption and depreciation-cum-obsolescence factors. Assuming a trapezoidal shape for the adoption curve, in order to define the entire profile of supply shifts over time, we need to define the following parameters:

- research lag in years - I_R
- adoption lag (years from initial adoption to maximum adoption) - I_A
- maximum lag (years from maximum adoption to eventual decline) - I_M
- decline lag (years from the beginning to the end of the decline) - I_D

Then we can define the supply shifts (in the price direction) for region i in each year t as follows:

$$\begin{aligned}
 k_{i,t} &= 0 && \text{(for } 0 \leq t \leq I_R \text{)} \\
 k_{i,t} &= k_i^{MAX} (t - I_R) / I_A && \text{(for } I_R < t \leq I_R + I_A \text{)} \\
 k_{i,t} &= k_i^{MAX} && \text{(for } I_R + I_A < t \leq I_R + I_A + I_M \text{)} \\
 k_{i,t} &= k_i^{MAX} \frac{I_R + I_A + I_M + I_D - t}{I_D} && \text{(for } I_R + I_A + I_M < t \leq I_R + I_A + I_M + I_D \text{)} \\
 k_{i,t} &= 0 && \text{(for } t > I_R + I_A + I_M + I_D \text{)}
 \end{aligned}$$

Figure 3 shows the trapezoidal adoption curve and shows how the parameters above (I_R, I_A, I_M , and I_D) may be used to define the entire curve. The S-shaped adoption curve is shown in Figure 4. The detailed derivation and calculation is illustrated in section 5.3.3 and appendix A5.4 of *Science Under Scarcity* by Alston *et al* (1995).

Spillover effects of research:⁴ The *spillover effects* from region i to other regions, j , are parameterized in relation to the supply shifts in region i , implicitly assuming the same adoption curve applies in every region.

⁴ The spillover coefficients, q_{ji} , are defined as if they were constant for all types of research-induced supply shifts and, for a given technological change, constant over time, implying that the relative shifts always occur in fixed proportion. These might not be reasonable restrictions for all problems. Between agroecological zones i and j , the

$$k_{j,t} = \mathbf{q}_{ji} k_{i,t} \text{ for all } i \text{ and } j \quad (5)$$

where

$$\mathbf{q}_{ji} = \text{supply shift in } j \text{ due to research-induced supply shift in } i \text{ (} \mathbf{q}_{ii} = 1 \text{)}$$

With-Research Supply and Demand

To model the with-research case (denoted by superscript R on all relevant variables and parameters), we take the intercepts from the without-research case (but include the effects of exogenous supply growth), add the effect of the supply shift to them, and include the result in the supply equation:

$$\mathbf{a}_{j,t}^R = \mathbf{a}_{jt} + k_{jt} \mathbf{b}_j \quad (6)$$

The models for supply and demand that reflect the local and spillover effects of research are

$$Q_{i,t}^R = \mathbf{a}_{it}^R + \mathbf{b}_i PP_{i,t}^R \quad (7a)$$

$$C_{i,t}^R = \mathbf{g}_{it} + \mathbf{d}_i PC_{i,t}^R \quad (7b)$$

The only substantive difference from the corresponding without-research equations (1a and 1b) is in the supply intercept, but as noted above, the prices and quantities are labeled differently (the R superscript) to distinguish them from the without-research values:

- quantity consumed in each region - $C_{i,t}^R$
- quantity produced in each region - $Q_{i,t}^R$
- producer price in each region - $PP_{i,t}^R$
- consumer price in each region - $PC_{i,t}^R$

Market-Clearing Rules

spillover relationships are very likely to differ among commodities, among types of technological changes for a given commodity, and over time for a given technological change and a given commodity. For some problems, it might be necessary to redefine the spillover matrix for different types of technologies and different times after release of a technology.

For all of the scenarios to be considered, there is an overall quantity clearing rule to the effect that the sum of quantities supplied equals the sum of quantities demanded in each year. Considering n regions,

$$Q_t = (Q_{1,t} + Q_{2,t} + \dots + Q_{n,t}) = C_t = (C_{1,t} + C_{2,t} + \dots + C_{n,t}) \quad (8)$$

All of the market-clearing rules express policies in terms of price wedges that permit differences between consumer and producer prices within and among regions consistent with clearing quantities produced and consumed.⁵

Free trade: The easiest case is that of free trade, where

- with-research prices: $PP_{i,t}^R = PC_{i,t}^R = PC_{j,t}^R = PP_{j,t}^R = P_t^R$
- without-research prices: $PP_{i,t} = PC_{i,t} = PC_{j,t} = PP_{j,t} = P_t$

are defined for all regions i and j and for any year t .

Making this substitution into each of the n regional supply-and-demand equations and then substituting them into equation (8) yields a solution for the equilibrium price for each year.

To simplify, let us define the following aggregated parameters for each year, t :

- $\mathbf{g}_t = \mathbf{g}_{1t} + \mathbf{g}_{2t} + \dots + \mathbf{g}_{nt}$
- $\mathbf{a}_t = \mathbf{a}_{1t} + \mathbf{a}_{2t} + \dots + \mathbf{a}_{nt}$
- $\mathbf{a}_t^R = \mathbf{a}_{1t}^R + \mathbf{a}_{2t}^R + \dots + \mathbf{a}_{nt}^R$
- $\mathbf{d}_t = \mathbf{d} = \mathbf{d}_{10} + \mathbf{d}_{20} + \dots + \mathbf{d}_{n0} < 0$
- $\mathbf{b}_t = \mathbf{b} = \mathbf{b}_{10} + \mathbf{b}_{20} + \dots + \mathbf{b}_{n0} > 0$

Then the without-research and the with-research market-clearing prices under free trade are given by

$$P_t = (\mathbf{g}_t - \mathbf{a}_t) / (\mathbf{b} - \mathbf{d}) \quad (9a)$$

$$P_t^R = (\mathbf{g}_t - \mathbf{a}_t^R) / (\mathbf{b} - \mathbf{d}) \quad (9b)$$

⁵ Transportation costs influence trade among countries and should theoretically be incorporated into the analysis if possible. However, accurate calculation of these costs is often difficult because it requires knowing the transportation differentials for each commodity between the home country being studied and each of its major trading partners, as well as the pattern of commodity flows. If international research spillovers are included in the analysis, either (a) information should be collected on the likely destinations and transportation costs between the home country and each other country involved so that a relatively accurate assessment can be made of the price wedge to be driven between the excess-supply and excess-demand curves or (b) transportation costs should be ignored. When regional analyses within a country are being conducted, regional transportation costs also may be needed.

These are always positive numbers, with $P_t > P_t^R$, because the intercepts on the *quantity* axis satisfy $g_t > a_t^R > a_t$ - unless we make a mistake such as letting supply grow too fast relative to demand.⁶

We can substitute the results for prices from equations (9a) and (9b) into the regional supply-and-demand equations to compute regional quantities produced and consumed with and without research and, as we shall see later, then calculate the regional consumer and producer welfare effects.

Generalized taxes and subsidies: We can define a general solution for a large variety of tax or subsidy regimes by setting out a general model in which a *per unit* tax is collected from consumers in every region and from producers in every region.

- T_i^C = per unit consumer tax in region i
- T_i^Q = per unit producer tax in region i

Different policies can be represented as different combinations of taxes and subsidies

- consumption tax in region i at T_i per unit: $T_i^C = T_i$; $T_i^Q = 0$
- production tax in region i at T_i per unit: $T_i^C = 0$; $T_i^Q = T_i$
- export tax in region i at T_i per unit: $T_i^C = -T_i$; $T_i^Q = T_i$
- import tariff in region i at T_i per unit: $T_i^C = T_i$; $T_i^Q = -T_i$

A subsidy is a negative tax, so it is also possible to use these to represent subsidies on output, consumption, imports, or exports. One way to think about this is to imagine a region with no taxes or subsidies in which the prices to producers and consumers are $P_t = PC_t = PP_t$ and $P_t^R = PC_t^R = PP_t^R$. Thus, P_t (expressed in common currency units, either local currency or \$US) is the border price for an exporter or an importer whose internal consumer or producer prices will be equal to that price in the absence of any domestic distortions. The arbitrage rules are that the prices in all regions are equal to

- $PP_{i,t} = P_t - T_i^Q$
- $PC_{i,t} = P_t + T_i^C$

⁶ For instance, we could violate this condition by setting the *autonomous* growth rate of supply so much greater than the *autonomous* growth rate of demand that in some set of future projections a point would be reached where supply and demand did not cross in the positive orthant – i.e., the *quantity* intercept of supply would become greater than the *quantity* intercept of demand in either the with- or without-research case.

- $PP_{i,t}^R = P_t^R - T_i^Q$
- $PC_{i,t}^R = P_t^R + T_i^C$

for all regions i and j and for any year t .

Making this substitution into each of the n regional supply-and-demand equations and substituting them into equation 9 yields a solution for the equilibrium price for each year. As for the case of free trade, let us define the following aggregated parameters for each year:

- $\mathbf{g}_t = \mathbf{g}_{1t} + \mathbf{g}_{2t} + \dots + \mathbf{g}_{nt}$
- $\mathbf{a}_t = \mathbf{a}_{1t} + \mathbf{a}_{2t} + \dots + \mathbf{a}_{nt}$
- $\mathbf{a}_t^R = \mathbf{a}_{1t}^R + \mathbf{a}_{2t}^R + \dots + \mathbf{a}_{nt}^R$
- $\mathbf{d}_t = \mathbf{d} = \mathbf{d}_{10} + \mathbf{d}_{20} + \dots + \mathbf{d}_{n0} < 0$
- $\mathbf{b}_t = \mathbf{b} = \mathbf{b}_{10} + \mathbf{b}_{20} + \dots + \mathbf{b}_{n0} > 0$

In addition, we can define the following aggregated demand-and supply shifts in the quantity direction because of consumer and producer taxes:

- $T_t^C = T_{1t}^C \mathbf{d}_{10} + T_{2t}^C \mathbf{d}_{20} + \dots + T_{nt}^C \mathbf{d}_{n0}$
- $T_t^Q = T_{1t}^Q \mathbf{b}_{10} + T_{2t}^Q \mathbf{b}_{20} + \dots + T_{nt}^Q \mathbf{b}_{n0}$

$$P_t = (\mathbf{g}_t + T_t^Q + T_t^C - \mathbf{a}_t) / (\mathbf{b} - \mathbf{d}) \quad (10a)$$

$$P_t^R = (\mathbf{g}_t + T_t^Q + T_t^C - \mathbf{a}_t^R) / (\mathbf{b} - \mathbf{d}) \quad (10b)$$

To check the signs intuitively, taxes on production in all regions will raise the equilibrium world trading price P_t –which is equal to the producer price in any country or region with no producer taxes and the consumer price in any country or region with no consumer taxes. Taxes on consumption in all regions will lower it.⁷ Of course this hypothetical price, P_t , might not actually apply anywhere.

To compute the actual consumer and producer prices in any region, the results of equations (10a) and (10b) are substituted into the arbitrage (market-clearing) rules given above (under the heading “generalized taxes and subsidies”). Then the individual prices can be used in the individual supply-and-demand equations (equations (1) and (7)) to compute quantities with

⁷ A positive value of T_i^Q for all i leads to a *positive* value of T_t^Q and thus a higher value of P_t . A positive value of T_i^C for all i leads to a *negative* value of T_t^C (because the demand slopes $\mathbf{d}_{i,0}$ are negative numbers) and a lowering of the price, P_t .

and without research, and from there to compute surplus effects. Notice that this set of results includes the free-trade model as a special case (i.e., when all of the taxes and subsidies are zero).

The small-country case: The small-country case can be represented in this model without modification. However, to do that requires getting information—that is not useful otherwise—on quantities produced and consumed in the rest of the world. The alternative is to define the market-clearing price for equations (10a) and (10b) as an exogenous parameter:

$$P_t = P_t^R = \bar{P}_t$$

It might require defining a growth rate for P_t , to obtain a series of exogenous world prices based on a starting value for P_0 . Then corresponding quantities can be obtained by substituting into the relevant supply-and-demand equations.

Other policies: Quantitative restrictions on production or trade can be treated approximately as tax/subsidy equivalents with a little care to distribute “tax revenue” as quota rents. The approximation is somewhat unreliable in a dynamic model, but it might suffice for our purposes. A target price, deficiency-payment scheme might involve more work. Conceptually, the approach is to define target price and allow it to determine output in regions where it applies. Then, with that supply as exogenous, supply equations in the other regions and demand equations in all regions would interact to determine price.

Welfare Effects

The following equations for welfare effects should be correct for most (if not all) types of policies (i.e., market-clearing rules).

$$\Delta PS_{j,t} = k_{j,t} + PP_{j,t}^R - PP_{j,t}][Q_{j,t} + 0.5(Q_{j,t}^R - Q_{j,t})] \quad (11a)$$

$$\Delta CD_{j,t} = (PC_{j,t} - PC_{j,t}^R)[C_{j,t} + 0.5(C_{j,t}^R - C_{j,t})] \quad (11b)$$

$$\Delta GS_{j,t} = T_{jt}^C(C_{j,t}^R - C_{j,t}) + T_{jt}^Q(Q_{j,t}^R - Q_{j,t}) \quad (11c)$$

where

$\Delta PS_{j,t}$ = producer research benefit in region j in year t

$\Delta CS_{j,t}$ = consumer research benefit in region j in year t

$\Delta GS_{j,t}$ = government research benefit in region j in year t

Aggregation over Time and Interest Groups

The model so far is capable of generating an indefinitely long time series of prices, quantities, and economic surplus measures for the regions of interest for a range of tax or subsidy policies. The remaining problem is to aggregate those measures into summary measures of research benefits. For a given policy scenario, we have the measure of benefits- $\Delta PS_{i,t}, \Delta CS_{i,t}, \Delta GS_{i,t}$ - for each region in each time period.

The *real* discount rate must be defined for the computation of the present value of the stream of benefits. A reasonable approach is to fix a single value for all regions, interest groups and years so that

$$r_{i,t} = r_{j,s} = r$$

We need to define a relevant planning horizon. Thirty years should be adequate for most purposes if we are using discount rates of 5% per year or greater. The *present values* of benefits to interest groups are then defined as

$$\begin{aligned} VPS_i &= \sum_{t=0}^{30} \Delta PS_{i,t} / (1+r)^t \\ &= \Delta PS_{i,0} + \Delta PS_{i,1} / (1+r) \\ &\quad + \Delta PS_{i,2} / (1+r)^2 + \dots + \Delta PS_{i,30} / (1+r)^{30} \end{aligned} \quad (12a)$$

$$\begin{aligned} VCS_i &= \sum_{t=0}^{30} \Delta CS_{i,t} / (1+r)^t \\ &= \Delta CS_{i,0} + \Delta CS_{i,1} / (1+r) \\ &\quad + \Delta CS_{i,2} / (1+r)^2 + \dots + \Delta CS_{i,30} / (1+r)^{30} \end{aligned} \quad (12b)$$

$$\begin{aligned} VGS_i &= \sum_{t=0}^{30} \Delta GS_{i,t} / (1+r)^t \\ &= \Delta GS_{i,0} + \Delta GS_{i,1} / (1+r) \\ &\quad + \Delta GS_{i,2} / (1+r)^2 + \dots + \Delta GS_{i,30} / (1+r)^{30} \end{aligned} \quad (12c)$$

If a longer planning horizon is appropriate we can either simply increase the number of years from 30 (probably the best way) or approximate the effects beyond 30 years using an infinite series (which is risky when the markets are growing and research effects are depreciating). Then we are free to add these present values up across the different producing and consuming groups in whatever fashion we find useful.

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