

Factors driving horticulture productivity

USER GUIDE: USING THE PRODUCTIVITY MODEL



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1 About the model

Part of a wider project

This productivity model forms part of Hort Innovation's project Factors driving horticulture productivity (HA24004).

This project involved the examination of the drivers of productivity within the Australian horticulture industries. One of the outputs of the project is a modelling framework to develop scenarios for future horticulture productivity growth. These scenarios are then implemented using the economic models developed as part of project MT21010 Economic contribution of Australian Horticulture.

This spreadsheet-based version has been provided as simplified implementation of the full model. Users can input key assumptions (described in detail below) and the spreadsheet will calculate the implied values of industry value added resulting from those assumptions.

The core idea underlying the model is that improvements in productivity arise through the adoption of new technologies and innovations that, over time provide net returns to growers. Adoption itself is determined by a range of drivers which are captured in the model. By modifying these drivers, different productivity pathways can be simulated.

A tool to experiment

The model provides users with a tool to experiment with different productivity drivers. It can be used to:

- Develop scenarios for future planning of industry value added based on assumptions about the uptake of productivity improving technologies.
- Compare the implications of different productivity developments over time.
- Test the effect of changes in underlying adoption drivers.
- Assess the incremental effects of improved adoption outcomes.
- Analyse the sort of productivity assumptions that would be needed to achieve 'targets' for industry growth.

The model can, for example, be used to generate the 'benefits' side of analysis looking at the impacts, costs and benefits of research or extension activities within horticulture.

2 Key concepts

Use of the model assumes familiarity with the ideas set out in the final report for *Factors driving horticulture productivity (HA24004)*. Below, we briefly cover seven key concepts needed to understand the model.

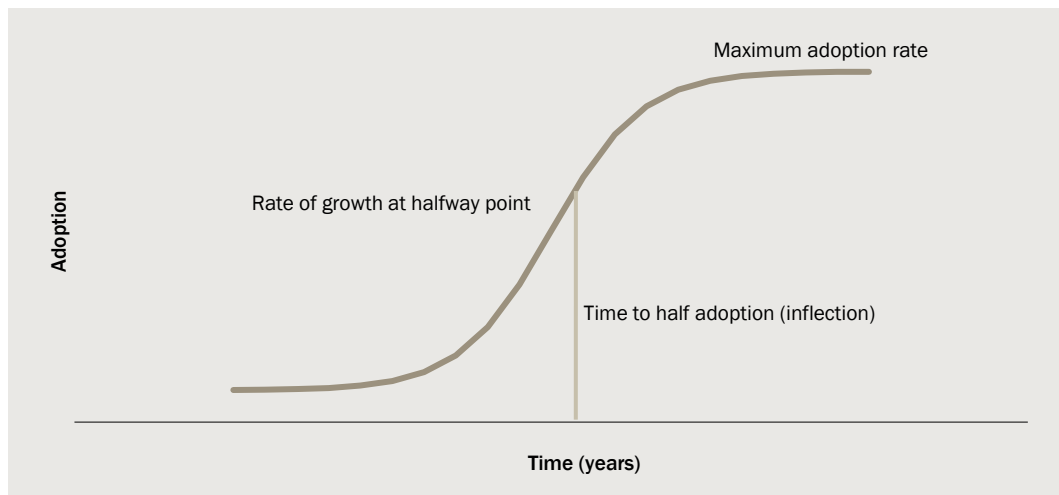
1. S-curve adoption

At the heart of the model lies the assumption that the adoption of new technologies follows a sequence of S-shaped adoption curves. Such curves are very common in technology analysis and provide a useful way to think through the development of scenarios.

Each S-curve is determined by three key parameters:

- the maximum adoption rate
- the year at which half adoption is achieved
- the speed of adoption (the slope of the S-curve at the halfway point)

2.1 Parameters of a standard S-curve



Data source: CIE.

2. Adoption of four groups of innovation options

Examination of the wide range of potential innovations available to producers suggests that a useful way of analysing and organising these is through four groups of innovation options. These are:

- **Production cost analysis:** Building the skills and capability to understand cost drivers and profitability. This allows enterprises to modify operations and discontinue unproductive activities or practices.
- **Automated farm data collection:** Using digital technologies to support real-time management decisions. This involves capturing, processing, and operationalising data and information to inform farm practices and enable more data-driven farm management.
- **Machine learning (ML) and artificial intelligence (AI):** Using advanced analytics to support better decision-making. ML and AI enable enterprises to interrogate data, uncover patterns, and understand the detailed dynamics of enterprise performance. This opens up new possibilities for agronomic and related practices.
- **Mechanisation and automation:** Applying physical automation in farm-based production (picking and spraying, for example), packing and transport. While this overlaps with data collection and AI, this group focuses on the physical implementation and other forms of automated interaction with the relevant crop.

The model allows users to choose the adoption parameters for each of these four innovation groupings.

3. The gains at full adoption

Adoption of each of these sets of technologies is expected to lead to a particular percentage in productivity gain for horticulture industries. For example, systematic cost accounting has been estimated to lead to increases in productivity of around 10 per cent. The source of this information is set out in the full report associated with the project.

The model allows the user to choose the value of this productivity increase once the technology has been adopted. The report underlying [Factors driving horticulture productivity](#) provides some guidance about potential values, but users are free to choose whatever values they see as most appropriate.

4. Labour productivity or multifactor productivity

The model allows the simulation of either labour productivity — which measures the efficiency with which labour is used in the industry — or multifactor productivity which covers the efficiency of all factors of production (labour along with land, capital and materials inputs).

5. Results for value added

Results are reported in terms of industry value added.

We use value added for the comparison rather than the value of farm gate production, as it better reflects the gains that arise from productivity increases. See box 2.2.

2.2 Gross value of production (GVP) versus value added (VA)

Understanding how we measure the impact of productivity is critical. While GVP measures total output, VA offers a more useful picture of true economic contribution of productivity increases.

By definition:

- **GVP:** The total market value of all products sold. It is made up of the sum of VA and intermediate input costs.

$$\text{GVP} = (\text{VA}) + (\text{intermediate input costs})$$

Intermediate inputs are all the goods and services bought from other industries and used up in production (fertiliser, herbicides, power, fuel, office supplies, packaging, irrigation materials, transport costs, etc.).

On average in horticulture, 36 per cent of GVP is spent on intermediate inputs.

- **VA:** The value created by the industry after accounting for the cost of inputs purchased from other sectors. It represents the net wealth generated by the horticulture industry itself.

$$\text{VA} = (\text{returns to capital}) + (\text{returns to land}) + (\text{returns to labour})$$

Returns to capital and returns to land combined can be thought of as **profit**.

Why use VA to measure the effect of changes in productivity?

- Isolates true value creation: VA removes external input costs, revealing the wealth created directly by the industry's own efforts.
- Better measures the returns to efficiency: VA directly increases when a farm reduces intermediate costs, even if GVP is stable. This accurately shows efficiency gains (doing more with less). VA will also capture productivity improvements even if GVP declines (ie. where reduced input costs outweigh increases in production).
- Aligns with profit & wages: VA directly indicates funds available for profits and wages. If profits do not increase, growers are unlikely to adopt the productivity measure.

Productivity gains can be hidden if we only look at GVP. Therefore, VA is a better measure of the gains that arise from a productivity increase, reflecting changes in profits plus the change in the industry's ability to pay workers.

6. Questionnaire for adoption parameters

To provide some guidance in the choice of the adoption parameters, the model includes a questionnaire where users can rank key factors determining adoption. The model will then generate estimates of each of the adoption parameters and users may subsequently input these into the adoption settings.

7. Horticulture industries covered

The model covers 42 individual horticulture growing industries and six processing sectors (table 2.3). Users can choose which industry they wish to analyse.

2.3 Industry coverage

Number	Industry	Number	Industry
1	Apples	25	Carrots
2	Pears and nashis	26	Onions
3	Summerfruit	27	Pumpkins
4	Cherries	28	Sweet corn
5	Strawberries	29	Peas and beans
6	Rubus	30	Lettuce
7	Kiwi fruit	31	Broccoli
8	Oranges	32	Cauliflower
9	Mandarins	33	Capsicums; Chillies & Peppers
10	Other citrus	34	Tomatoes - processing
11	Grapes - Table and Other	35	Tomatoes - fresh
12	Grapes - Total Dried	36	Asparagus
13	Other temperate fruit	37	Mushrooms
14	Bananas	38	Garlic and herbs
15	Pineapples	39	Other vegetables
16	Avocados	40	Nursery
17	Mangoes	41	Cultivated turf
18	Melons	42	Cut flowers
19	Other tropical fruit	43	Frozen potatoes
20	Olives	44	Canned tomatoes
21	Macadamia	45	Other processed vegetables
22	Almonds	46	Processed fruits and jams
23	Other nuts	47	Orange and other juice
24	Potatoes	48	Olive oil

Source: CIE HI_LINK model.

3 *Navigating the model*

Components of the model

The model contains four visible worksheets:

- *Instructions* — a brief guide on how to use the spreadsheet model
- *Questionnaire* — helps users in choosing adoption parameter values by guiding them through key considerations
- *Adoption profile* — the main input sheet where users input productivity and adoption parameter assumptions
- *Results* — a sheet which presents value added results for the chosen industry. It also includes space for users to undertake additional calculations with the results.

In addition to these, the model also contains a number of hidden worksheets which are used to perform intermediate calculations.

4 Using the model

The sections below outline a typical workflow for undertaking analysis with the model.

Setting adoption parameters

The *Questionnaire* worksheet sets out a questionnaire designed to elicit values for the adoption parameters for a single innovation grouping, that can be subsequently used in the *Adoption profile* sheet. The use of this questionnaire set is optional and does not directly link to any subsequent calculations.

	A	B	C
1			
2	Provide a score for each of the factors listed		
3			
4	Driver	Question	Score (1-5)
5	Factors determining the maximum adoption rate		
6	Technical fit / agronomic compatibility	How many businesses in your industry meet the agronomic or technical pre-conditions for adopting the technology (1 = a few, 5 = many)?	5
7	Capital intensity vs. business size	Relative to annual revenue, how high is the upfront capital cost of adopting (1 = negligible, 5 = prohibitively high)?	1
8	Complementary infrastructure	Are the necessary complementary services (e.g., broadband, cold-chain, specialist technicians) widely available (1 = not available, 5 = available)?	5
9	Regulation & certification	Do regulations, licences or certification schemes materially restrict uptake (1 = not at all, 5 = very restrictive)?	1
10	Strategic substitutes	Are there low-cost substitute technologies that can deliver comparable benefits (1 = none, 5 = many strong substitutes)?	1
11	End-user heterogeneity	How uniform are skills, risk tolerance and land tenure across potential adopters (1 = very uniform, 5 = highly varied)?	1
12		Average	5
13			
14	Factors determining the time to half adoption		
15	Cost-decline & pay-back period	At today's prices, what is the typical pay-back period in years (1 = <1 yr, 5 = >10 yrs)?	1
16	Asset replacement cycle	How often do businesses replace the current asset/processes this technology would supersede (1 = yearly, 5 = >15 yrs)?	1
17	Visibility of demonstrators	How easy is it for potential adopters to observe working demonstrations or peer examples (1 = not easy, 5 = very easy)?	5
18	Supply-chain ramp-up	Can suppliers scale production quickly if demand surges (1 = hard to scale, 5 = easily scale)?	5
19	Policy / price shocks	Are there policy instruments or commodity-price trends that could accelerate adoption (1 = no instruments, 5 = many instruments)?	5
20	Macroeconomic & credit conditions	How accessible is credit and how stable are relevant input/output prices (1 = not accessible, unstable, 5 = easily accessible)?	5
21		Average	5
22			
23	Factors determining the speed of adoption		
24	Network density / social contagion	How tight-knit are local or industry networks for sharing know-how and success stories (1 = not tight knit, 5 = very tight knit)?	5
25	Marketing & extension intensity	What is the level of active promotion, field-days or advisory support for the technology (1 = negligible, 5 = high)?	5
26	Modularity & ease of trial	Can the technology be trial-installed on a small scale before full roll-out (1 = hard to trial, 5 = easy to trial)?	5
27	Competitive pressure	Do adopters gain a cost or quality advantage that pressures rivals to follow quickly (1 = little advantage, 5 = high advantage)?	5
28	Supply-chain elasticity	Is there sufficient delivery & service capacity to deliver rapid roll-outs (1 = insufficient, 5 = more than sufficient)?	5
29	Risk & complexity	How great are the perceived technical or other risks and learning requirements? (1 = very low, 5 = very high)	1
30		Average	5

Users assign ranking scores in column C (1 to 5) in response to each question listed in column B. These questions reflect key factors identified in the research as influencing innovation adoption outcomes.

If preferred, users can manually choose these parameters and enter them into the cells of the *Adoption profile* sheet, as described below.

Based on the input scores, the model then calculates the implied adoption parameters (displayed in rows 34 to 35).

	A	B
32	Implied values for adoption spreadsheet	
33		
34	Maximum adoption rate	90%
35	Year of half adoption	2026
36	Speed of adoption	Very quick

If they wish, users can repeat these questions for each of the four innovation groups.

Setting up scenarios

Choice of industry and type of productivity

Cell C2 of the *Adoption profile* worksheet allows the user to choose the horticultural industry of interest from a dropdown menu. Cell C3 allows the user to choose from a dropdown menu, whether to simulate multifactor productivity or labour productivity.

	A	B	C	D	E	F
1						
2	Choose Horticulture sector:		Apples		(Drop down menu)	
3	Choose type of productivity:		Multifactor productivity		(Drop down menu)	

Choice of productivity and adoption parameters

The block of cells from C8 to F11 provides the user the opportunity to select values for:

- The maximum productivity benefit for each group of productivity enhancers (the cells in C8 to C11)
- The parameters of the adoption curve for each of these blocks. These parameters are:
 - The maximum adoption rate (cells D8 to D11)
 - The year when adoption reaches half the maximum (cells E8 to E11)
 - The speed with which maximum adoption is achieved (cells F8 to F11). For the speed parameters in F8 to F11 the user chooses from a dropdown menu in these cells. Options are very quick, quick, normal, slow, very slow.

	B	C	D	E	F
5	Scenario 1	(Choose values for darker grey cells that are bold)			
		Additional productivity with full (%) adoption	Maximum adoption	Year when the adoption achieves half of the maximum adoption rate	Speed to reach maximum adoption
6	Source	(input value)	(input value)	(input value)	(choose from drop down menu)
7		%pa	%	Year	
8	Production cost analysis	10%	90%	2026	Quick
9	Automated farm data collection	12%	63%	2033	Normal
10	ML and AI	7%	56%	2033	Normal
11	Mechanisation and automation	8%	49%	2030	Normal

The model contains two blocks of assumptions which allow the user to compare two different scenarios.

	B	C	D	E	F	G	H	I	J	K	L	M	N
5	Scenario 1	(Choose values for darker grey cells that are bold)						Scenario 2	(Choose values for darker grey cells that are bold)				
		Additional productivity with full (%) adoption	Maximum adoption	Year when the adoption achieves half of the maximum adoption rate	Speed to reach maximum adoption (choose from drop down menu)	For reference: implied midpoint year if initial adoption is 1% in 2025			Additional productivity with full (%) adoption	Maximum adoption	Year when the adoption achieves half of the maximum adoption rate	Speed to reach maximum adoption (choose from drop down menu)	For reference: implied midpoint year if initial adoption is 1% in 2025
6	Source	(input value) %pa	(input value) %	(input value) Year				Source	(input value) %pa	(input value) %	(input value) Year		
7													
8	Production cost analysis	10%	90%	2026	Quick	2031		Production cost analysis	12%	50%	2033	Normal	2033
9	Automated farm data collection	12%	63%	2033	Normal	2033		Automated farm data collecti	12%	63%	2033	Quick	2031
10	ML and AI	7%	56%	2033	Normal	2033		ML and AI	2%	56%	2031	Quick	2030
11	Mechanisation and automation	8%	49%	2030	Normal	2033		Mechanisation and automati	5%	49%	2030	Normal	2033

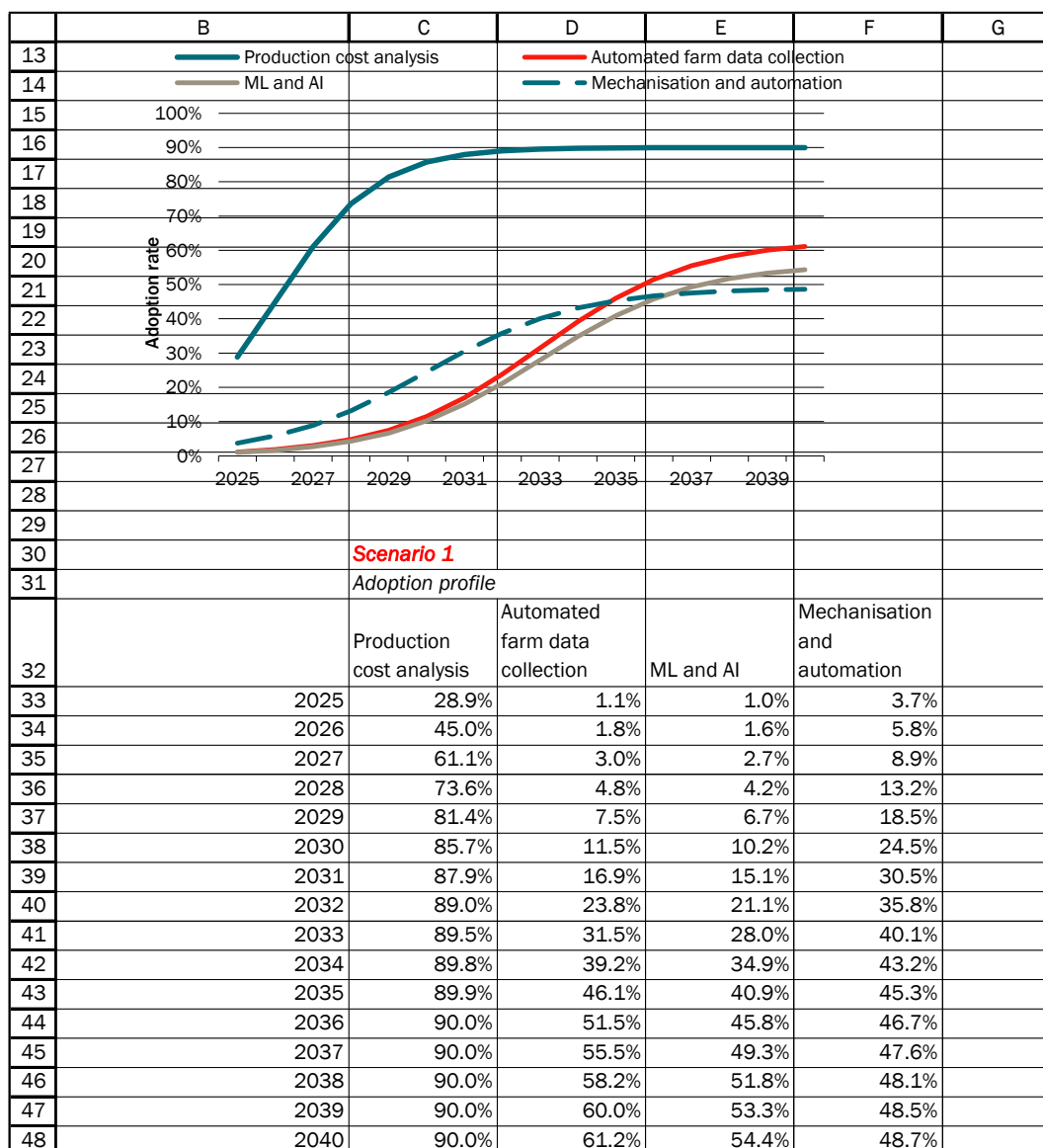
4.1 Technical note

As a guide for technical users, the model also displays calculated values (in cells G8 to G11 and N8 to N11) showing the implied year of half maximum adoption if adoption were to be one per cent in 2025. This feature is designed to assist in calibrating the adoption curve: it has no effect in the overall model and is provided for information only.

Model results and calculations

'Adoption profile' worksheet

Directly below the assumptions blocks (either for Scenario 1 or Scenario 2) is an adoption profile chart implied by the assumptions, along with a table of adoption rates.



Scenario 1
Adoption profile

Implied productivity

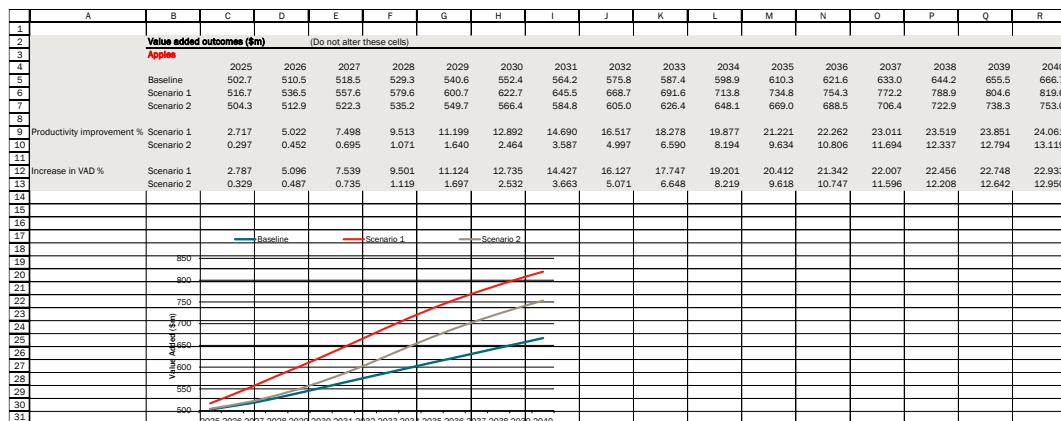
Below this, starting in row 53, is the implied productivity increase by year for each of the components and in total.

	B	C	D	E	F	G	
51		Implied productivity improvement					
52		Production cost analysis	Automated farm data collection	ML and AI	Mechanisation and automation	Total	
53	2025	2.89%	0.14%	0.07%	0.30%	3.39%	
54	2026	4.50%	0.22%	0.11%	0.47%	5.30%	
55	2027	6.11%	0.36%	0.19%	0.72%	7.37%	
56	2028	7.36%	0.57%	0.30%	1.05%	9.28%	
57	2029	8.14%	0.90%	0.47%	1.48%	10.99%	
58	2030	8.57%	1.38%	0.72%	1.96%	12.63%	
59	2031	8.79%	2.03%	1.05%	2.44%	14.32%	
60	2032	8.90%	2.85%	1.48%	2.87%	16.10%	
61	2033	8.95%	3.78%	1.96%	3.20%	17.90%	
62	2034	8.98%	4.71%	2.44%	3.45%	19.58%	
63	2035	8.99%	5.53%	2.87%	3.62%	21.00%	
64	2036	9.00%	6.18%	3.20%	3.73%	22.11%	
65	2037	9.00%	6.66%	3.45%	3.81%	22.91%	
66	2038	9.00%	6.99%	3.62%	3.85%	23.46%	
67	2039	9.00%	7.20%	3.73%	3.88%	23.81%	
68	2040	9.00%	7.34%	3.81%	3.89%	24.04%	

Value added results for the chosen industry — Results worksheet

In the worksheet *Results*, the model sets out the value-added path (to 2040) for the selected industry.

This shows (in \$ million) value added for the selected industry implied by the productivity shocks. The sheet also provides a graph of the results.



The value added results from the user-defined scenario are compared with the original baseline from the report MT21010 Economic contribution of Australian Horticulture.

Below these results is an area of the worksheet where users can undertake their own calculations using the results.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
34	Use the area below for any additional calculations on the results (some examples provided)																		
35																			
36																			
37		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040		
38	Difference between scenarios	12.4	23.5	35.3	44.4	51.0	56.4	60.7	63.7	65.2	65.8	65.9	65.9	65.9	66.0	66.2	66.6		
39																			
40	Present value of difference		\$661.88																
41																			
42	Value added growth rates	(% per year)																	
43	Baseline	2.0%																	
44	Scenario 1	3.2%																	
45	Scenario 2	2.9%																	



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