Economics of Indoor Agriculture
OpEx: Fixed and Variable Costs

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CapEx and OpEx

CapEx and OpEx and the role they play in management strategies

CapEx: Capital Expenditures

- One-off
- Includes physical assets, such as buildings, equipment, machinery, and vehicles (PP&E)

OpEx: Operating Expenditures

- Recurring
- Fixed operating costs
- Variable Operating costs

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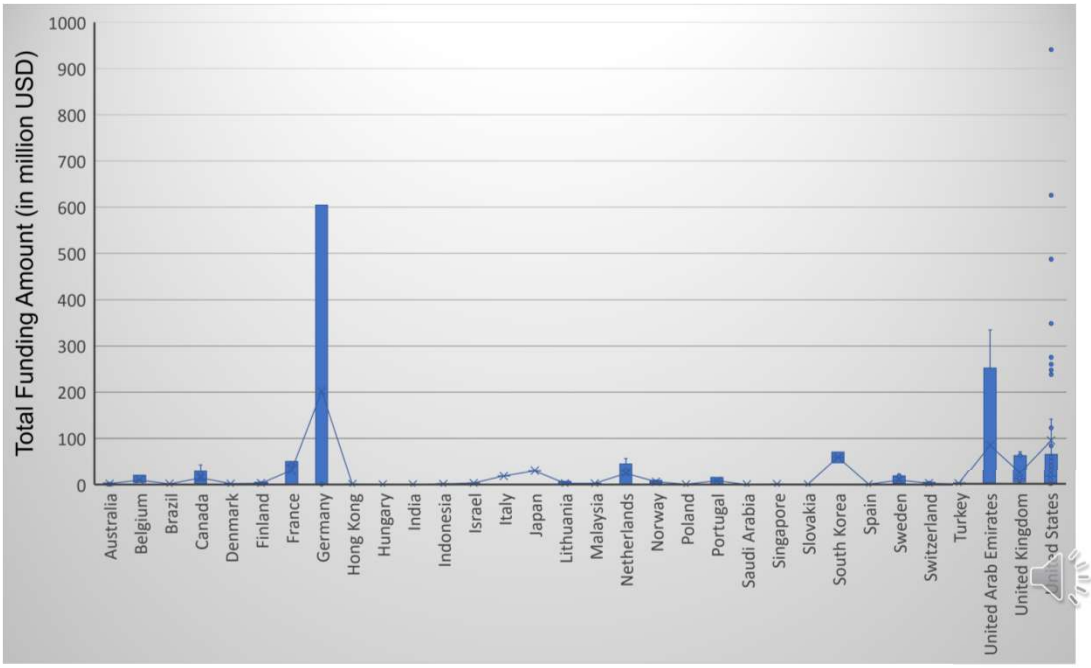

Source: Urban Vine: The Leading Indoor Farming Newsletter

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OpEx: Operating Expenditures

Fixed Costs: independent of output

- Depreciation of fixed assets
- Indirect labor
- Rental fees
- Maintenance and repair of equipment
- Advertising costs
- Phone and power overheads
- Property management costs
- Insurance

Variable Costs: changing with output

- Direct labor
- Water
- Energy
- Raw materials and supplies
- Consumables

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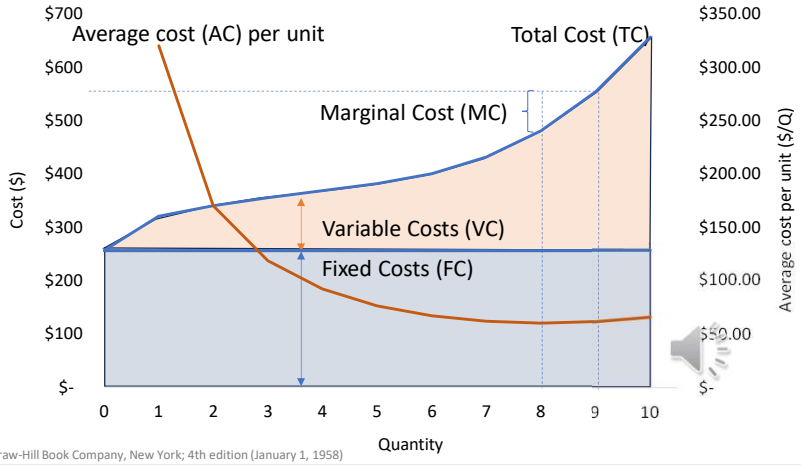
OpEx: Variable and Fixed Costs

After the overhead has been spread thin over many units, Fixed Costs can no longer have much influence on Average Costs

Quantity Q (1)	Fixed cost FC (2)	Variable cost VC (3)	Total cost TC = FC + VC (4)	Marginal cost per unit MC (5)	Average cost per unit AC = TC / Q (6)
0	$ 256	$ -	$ 256		
1	$ 256	$ 64	$ 320	$ 64	$ 320.00
2	$ 256	$ 84	$ 340	$ 20	$ 170.00
3	$ 256	$ 99	$ 355	$ 15	$ 118.33
4	$ 256	$ 112	$ 368	$ 13	$ 92.00
5	$ 256	$ 125	$ 381	$ 13	$ 76.20
6	$ 256	$ 144	$ 400	$ 19	$ 66.67
7	$ 256	$ 175	$ 431	$ 31	$ 61.57
8	$ 256	$ 224	$ 480	$ 49	$ 60.00
9	$ 256	$ 297	$ 553	$ 73	$ 61.44
10	$ 256	$ 400	$ 656	$ 103	$ 65.60



Source: Based on Samuelson, P. A. 1958. Economics: An Introductory Analysis. McGraw-Hill Book Company, New York; 4th edition (January 1, 1958)

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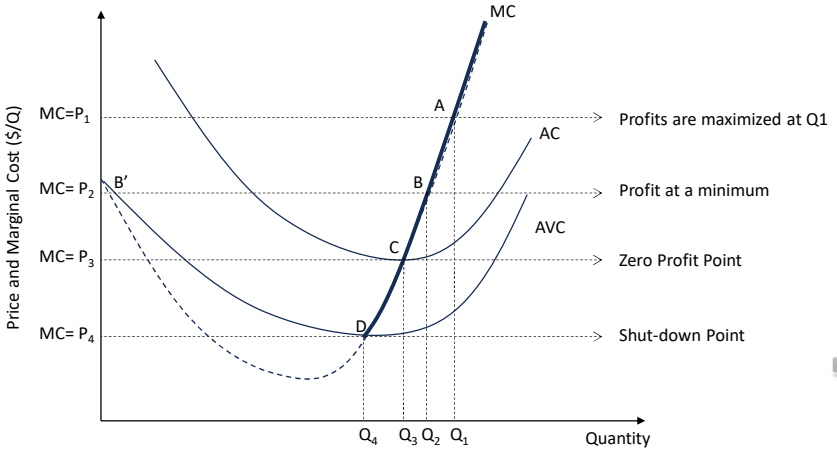
Market Prices and Marginal Cost

Marginal Costs as the short-run Supply Curve

- Equating MC to P can be a strategy to minimize losses
- MC is unaffected by Fixed costs



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Example: Hypothetical Indoor Farm

Production

- 'Seurat', 'Rouxai', 'Pascal' and 'Rex'.
- Produce is sold as lose leaves in 5 oz clamshell plastic packages.
- Light intensity at production stage is 200 PPFD, 16 hours/day
- Propagation area (seedling to transplant) has 8 levels
- Production area (transplant to harvest) has 4 levels

Operating costs

- Seeds: 0.04 US$/seed
- Substrate: 0.035 US$/unit
- Packaging material: 0.04 US$/unit
- Electricity costs: 0.10 US$/kWh
- Loading of energy (HVAC): 30%
- Production-related labor wages: 12.46 US$/hour
- Benefit loading: 20%
- Annual depreciation of technology: 145.57 US$/$m^2$ of total floor area
- Annual rent: 921 US$/$m^2$ of total floor area

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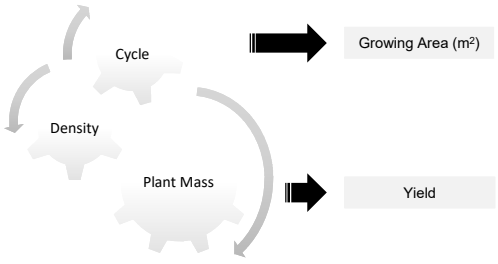
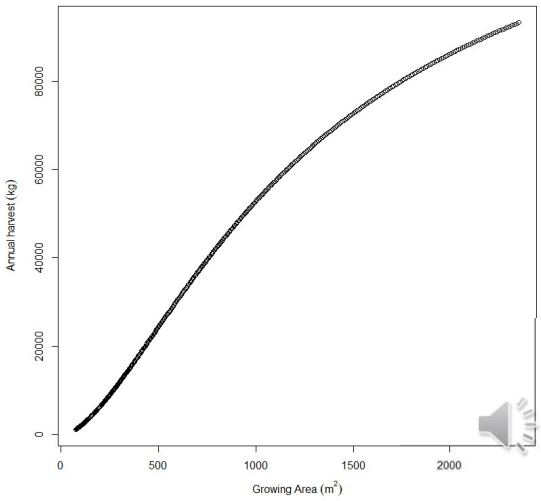
Annual Production in Indoor Farms





See the model's description in the "Planning Production Efficiency" lecture.

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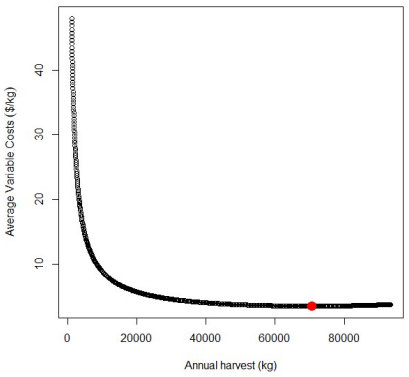
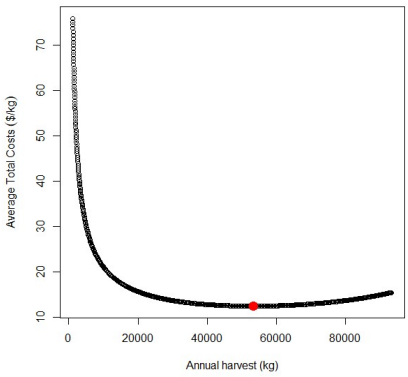
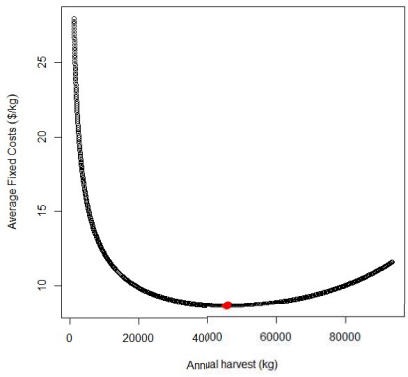
Average costs per unit (kg)







Min AVC = $3.55 Shut-down Point
Annual Production = 70,574 kg
Growing area = 1,434 m²

Min ATC = $12.40 Zero Profit Point
Annual Production = 53,339 kg
Growing area = 1,010 m²

Min AFC = $8.64
Annual Production = 45,653 kg
Growing area = 858 m²

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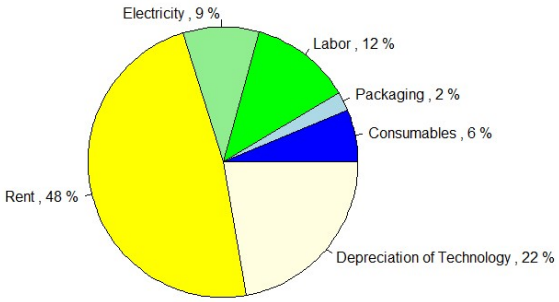
Fixed and Variable Costs (at Min ATC)

Quantity is set at Minimum ATC
Market price is $30.18/kg
Retailer margin is 40%

Distribution of Operating Costs



Farm Parameters	Unit	Value	Value
Total growing area (GA)	m²		1,010
Floor area	m²		345
Harvest cycle length (DAT)	days		21
Daily harvest	kg		148
Economic Results	**Unit**	**per annum**	**per m² of GA**
Total harvest	kg	53,339	52.8
Revenue	US$	965,859	956.63
Input costs: seeds and substrate	US$	41,850	41.45
Packaging cost	US$	15,025	14.88
Energy costs	US$	60,230	59.65
Labour costs	US$	79,849	79.09
Total Variable Operating Costs	US$	196,954	195.07
Rent	US$	317,419	314.39
Depreciation of Technology costs	US$	146,976	145.57
Total Fixed Operating Costs	US$	464,395	459.96
Economic Result	US$	304,510	301.50

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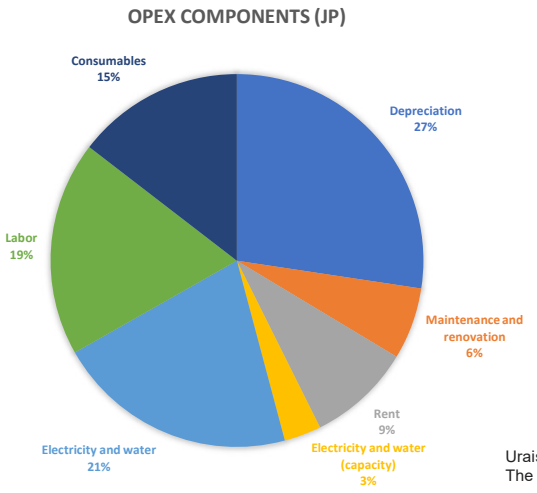
Fixed and Variable Costs



Fixed cost	Depreciation
	Maintenance and renovation
	Rent
	Electricity and water (capacity)
Variable costs	Electricity and water
	Labor
	Consumables

Uraisami, Kaz. (2018). Business Planning on Efficiency, Productivity, and Profitability: The Next Generation Indoor Vertical Farms. 10.1007/978-981-13-1065-2_6.

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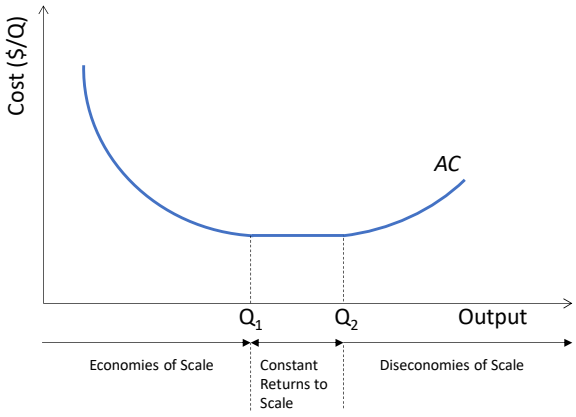
Economies of scale

An increase in efficiency as scale increases -> increasing returns to scale, or economies of mass production



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Economies of Scale

- Economies of scale
  - Automation, Specialization and division of labor;
  - Indivisibilities;
  - Multi-stage production – *Plant* economies of scale;
  - Organizational economies;
  - Spreading overheads;
  - Financial economies.
- Diseconomies of scale
  - For example, management problems, worker alienation, and complex production-line processes.

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Economies of Scope

When overhead costs, financial costs, and organizational economies can be shared among products

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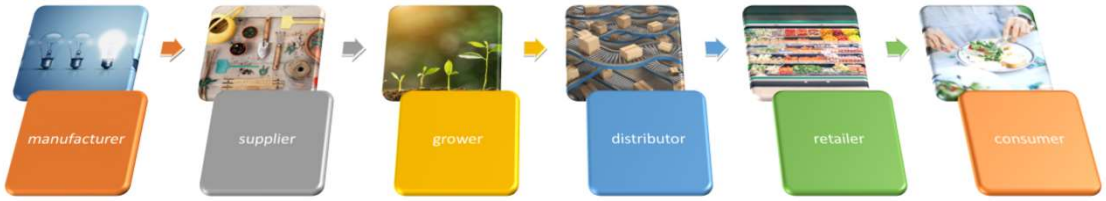
External Economies of Scale



As the industry grows, so does the network of supply agents, communications, skills, training facilities, distribution channels, specialized financial services

- Cost Reduction
- Access to Skilled Labor
- Knowledge Sharing and Collaboration
- Improved Infrastructure
- Enhanced Access to Markets
- Financial Services Support

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Thank you!

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