Game Design Math

Part 2: Game balancing

Aalto University, Game Analysis course

Perttu Hämäläinen 2021

Why?

1. Math can give you a consistent and roughly correct initial guesses
   - Final solution then iterated through playtesting & A/B testing

2. A spreadsheet or a Colab notebook can make it easier to update many things at once
   - Change one number to get and visualize, e.g., new character stats for all levels
   - A game prototype with a single level does not need a spreadsheet and design by math, but defining values using math is basically a form of automation needed when the game is scaled up to multiple levels, characters, weapons etc.
   - Especially relevant in games as a service, where you need to model and predict how the game should evolve over years, with players feeling like they make progress, and an engaging experience provided for both old and new players

Iain Compton:

"A lot of game design is done in an Excel sheet. As a rule of thumb, design starts in a text document and ends with a spreadsheet.

As a designer a **lot of things are dependent on numbers**. Experience points, damage, hit points, currency, etc. A lot of those have **complex inter-relationships** too. As a designer you will want to be able to **model things before making balance changes**. If you increase one number by a certain amount, how much does it affect a different number? How long does it take a player to go through your content? How much currency should a player have at a certain point in the game?"

Books
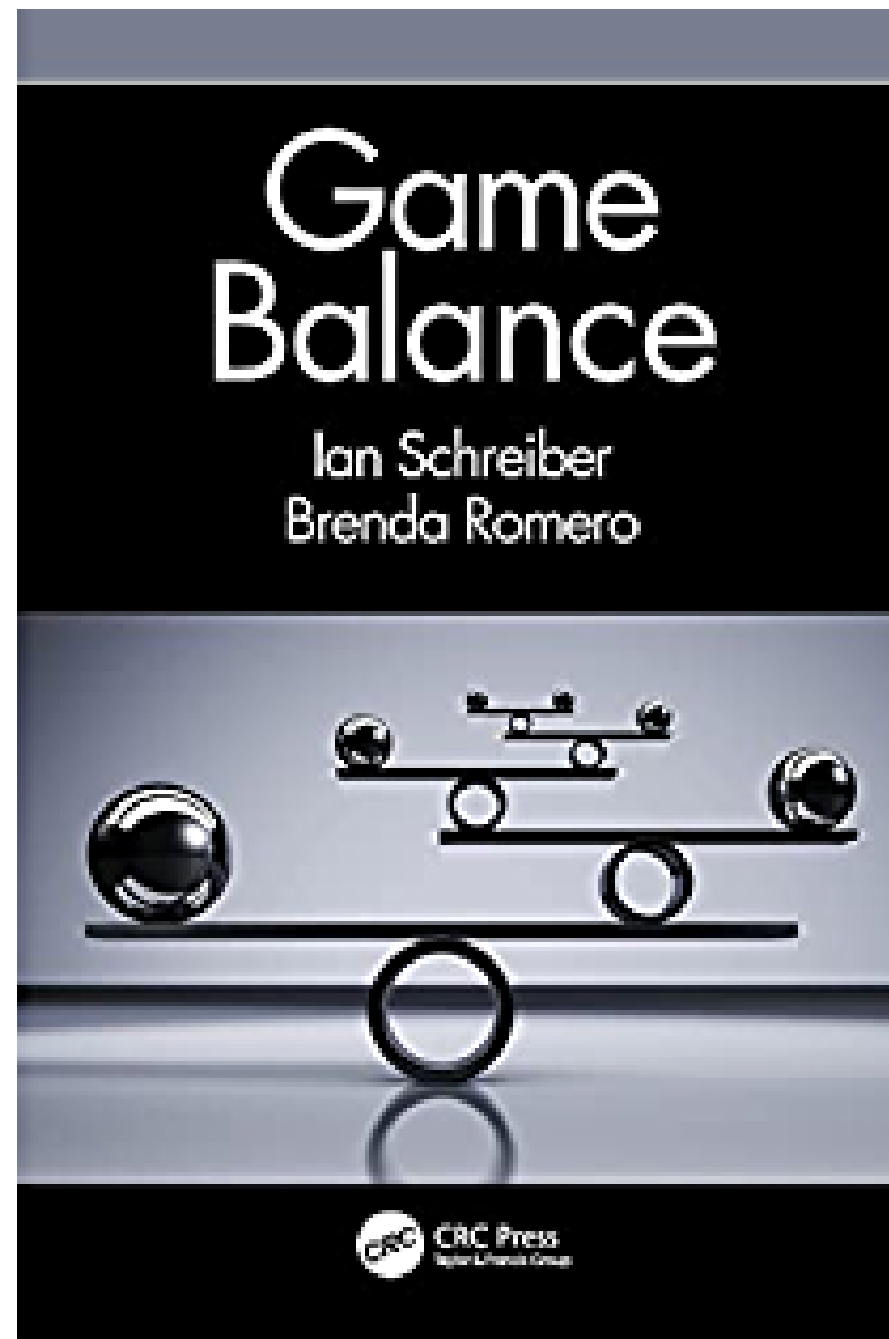
A highly marketable skill

- Especially in games as a service, knowing how to design and model game balance and economy can be crucial

- A final assignment from 2018 that landed Francesco Fontana his first game designer job at Wargaming Helsinki (shared with permission): https://docs.google.com/spreadsheets/d/1ziuQmP2XTDIGUFvi_R6Gl ClitmbPm47wAVpb1pAq7do/edit#gid=1054610195

Francesco has since worked at Rovio and is now a senior game designer at Savage Game Studios.

fx | `<b>Battlecry:</b> Summon a 1/1_Murloc Scout.`

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	NAME	CARD SET	TYPE	RARITY	TEXT	CLASS	MECHANICS	TYPE	HEALTH	ATTACK	REAL COST		BASIC COST	RAW GAME VALUE		RAW GAME VALUE (Basic Set Only)
2	Starving Buzzard	Basic	Minion	Free	never you summon a Beast, draw a	Hunter		Beast	2	3	5		2.5	-2.5		-2.5
3	Reckless Rocketeer	Basic	Minion	Free	Charge	Neutral	Charge		2	5	6		3.5	-2.5		-2.5
4	ormpike Comman	Basic	Minion	Free	Battlecry: Deal 2 damage.	Neutral	Battlecry		2	4	5		3	-2		-2
5	Tundra Rhino	Basic	Minion	Free	Your Beasts have Charge.	Hunter	Charge	Beast	5	2	5		3.5	-1.5		-1.5
6	Wolfrider	Basic	Minion	Free	Charge	Neutral	Charge		1	3	3		2	-1		-1
7	Ironforge Rifleman	Basic	Minion	Free	Battlecry: Deal 1 damage.	Neutral	Battlecry		2	2	3		2	-1		-1
8	Windspeaker	Basic	Minion	Free	y: Give a friendly minion Wi	Shaman	Windfury Battlecry		3	3	4		3	-1		-1
9	Novice Engineer	Basic	Minion	Free	Battlecry: Draw a card.	Neutral	Battlecry		1	1	2		1	-1		-1
10	Raid Leader	Basic	Minion	Free	Your other minions have +1 Attack.	Neutral	Aura		2	2	3		2	-1		-1
11	Gnomish Inventor	Basic	Minion	Free	Battlecry: Draw a card.	Neutral	Battlecry		4	2	4		3	-1		-1
12	Frostwolf Warlord	Basic	Minion	Free	n +1/+1 for each other friendly mini	Neutral	Battlecry		4	4	5		4	-1		-1
13	ormwind Champi	Basic	Minion	Free	Your other minions have +1/+1.	Neutral	Aura		6	6	7		6	-1		-1
14	Bluegill Warrior	Basic	Minion	Free	Charge	Neutral	Charge	Murloc	1	2	2		1.5	-0.5		-0.5
15	Silverback Patriarch	Basic	Minion	Free	Taunt	Neutral	Taunt	Beast	4	1	3		2.5	-0.5		-0.5
16	Dalaran Mage	Basic	Minion	Free	Spell Damage +1	Neutral	Spell Damage		4	1	3		2.5	-0.5		-0.5
17	Kor'kron Elite	Basic	Minion	Free	Charge	Warrior	Charge		3	4	4		3.5	-0.5		-0.5
18	Stormwind Knight	Basic	Minion	Free	Charge	Neutral	Charge		5	2	4		3.5	-0.5		-0.5
19	ooty Bay Bodygua	Basic	Minion	Free	Taunt	Neutral	Taunt		4	5	5		4.5	-0.5		-0.5
20	Archmage	Basic	Minion	Free	Spell Damage +1	Neutral	Spell Damage		7	4	6		5.5	-0.5		-0.5
21	Lord of the Arena	Basic	Minion	Free	Taunt	Neutral	Taunt		5	6	6		5.5	-0.5		-0.5
22	Boar	Basic	Minion	Common		Neutral		Beast	1	1	1		1	0		0
23	Sheep	Basic	Minion	Common		Neutral		Beast	1	1	1		1	0		0
24	Murloc Scout	Basic	Minion	Common		Neutral		Murloc	1	1	1		1	0		0
25	Skeleton	Basic	Minion	Common		Neutral			1	1	1		1	0		0
26	Searing Totem	Basic	Minion	Free		Shaman		Totem	1	1	1		1	0		0
27	Silver Hand Recruit	Basic	Minion	Free		Paladin			1	1	1		1	0		0
28	Magma Rager	Basic	Minion	Free		Neutral		Elemental	1	5	3		3	0		0
29	Core Hound	Basic	Minion	Free		Neutral		Beast	5	9	7		7	0		0
30	War Golem	Basic	Minion	Free		Neutral			7	7	7		7	0		0
31	Dragonling Mechan	Basic	Minion	Free	ry: Summon a 2/1 Mechanical D	Neutral	Battlecry		4	2	4		3	-1		-1
32	Nightblade	Basic	Minion	Free	cry: Deal 3 damage to the ene	Neutral	Battlecry		4	4	5		4	-1		-1
33	Murloc Tidehunter	Basic	Minion	Free	ttlecry: Summon a 1/1_Murloc	Neutral	Battlecry	Murloc	1	2	2		1.5	-0.5		-0.5
34	arsong Command	Basic	Minion	Free	Charge minions have +1 Att	Warrior	Charge Aura		3	2	3		2.5	-0.5		-0.5

Francesco says (1 year after the course):

"If you want to be a game design for mobile AND console or PC, you need to have a good understanding of the things you're going to learn in this course. It's crucial, even if you don't want to do any system heavy games, 3/4 of the games have some sort of system that needs to be designed and then balanced. Even narrative-focused indie games like Amnesia have systems like health, oil for the lamp etc, and those systems need to be crafted. So, enjoy this course and try to get as much as possible out of it if you want to do some game design in the future. Regarding my experience, I was hired mainly because I was able to showcase some practical balancing knowledge from this course."

The job interview process

- - 4 interviews
- - 10% my life and studies
- - 60% "Hey, I've got this Hearthstone Analysis I did few months ago, do you wanna check it out?"
- - 30% discussions about games and why certain companies made some game design choices here and there.

Job in practice:

- - 40% creating and balancing systems on google sheet and ensure that they can be implemented in the game with the current tools

- - 30% Designing features and writing detailed documentation about it

- - 30% define detailed UX flows and user paths for each feature

Game balancing

- Overall: determining the numbers/parameters of the game.
- Challenge level appropriate for the audience?
- Balance of starting positions?
- Balance of multiple strategies?
- Balance of objects such as cards, battle units?

Three ways of balancing

- Use math and simulations (transitive and intransitive relationships)
- Use your design instincts
- Use playtesting
- Generally, a good idea to start with math if it's feasible

Two main types of relations

- Transitive relationships: cost/benefit curves
- Intransitive relationships: rock-paper-scissors, every unit has both weaknesses and strengths, wins some but loses to others

Balancing intransitive relationships

- Key principle: every attack must have a counter
- Rock-paper-scissors is balanced because every choice has equal opportunity of winning and losing

Intransitive relationships in Clash Royale (rowwise)

|		WIN	LOSE
	LOSE		WIN
	WIN	LOSE	

Balancing transitive relationships

- Design based on "cost curves" – general relationships of variables such as item cost and item benefit (e.g., elixir cost vs. damage per second and hit points in Clash Royale)

- Rule of thumb: All units should have approximately equal cost/benefit ratio.

- Challenge: How to make at least some units feel very powerful at the same time?

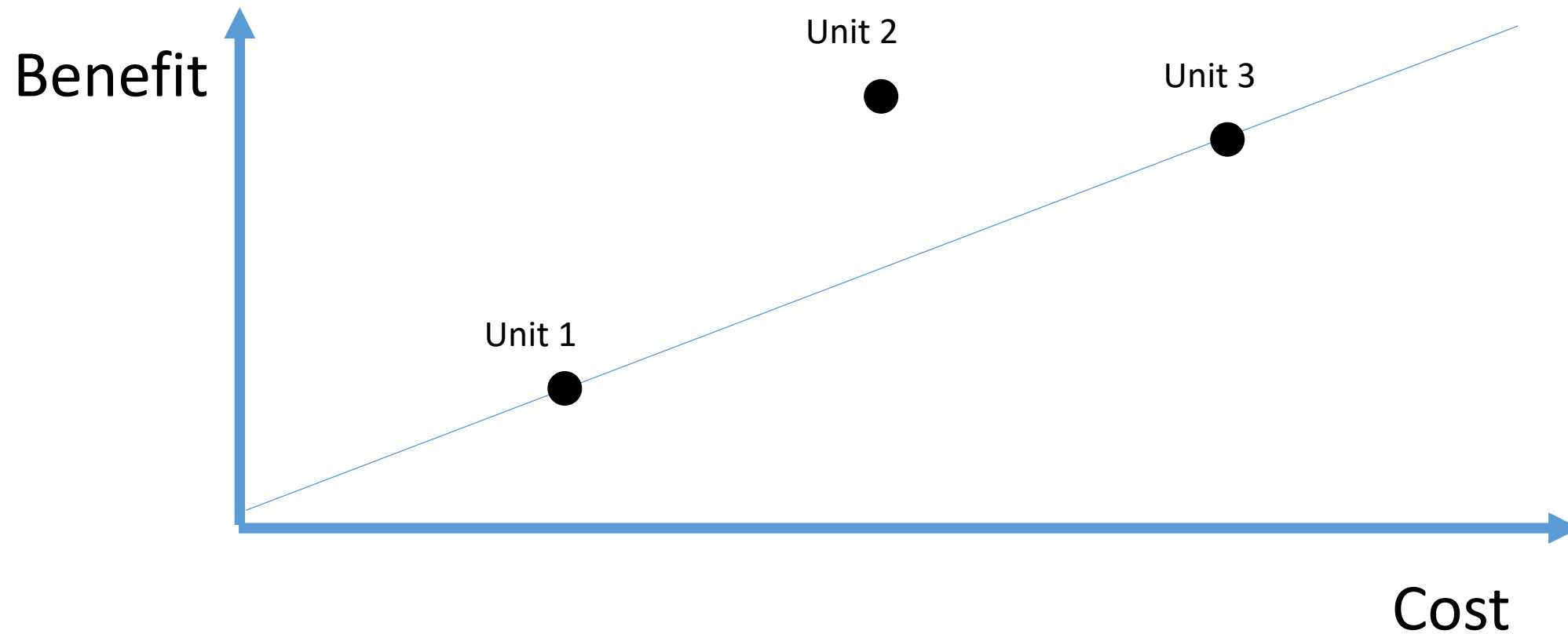# Linear cost curve: a reasonable default
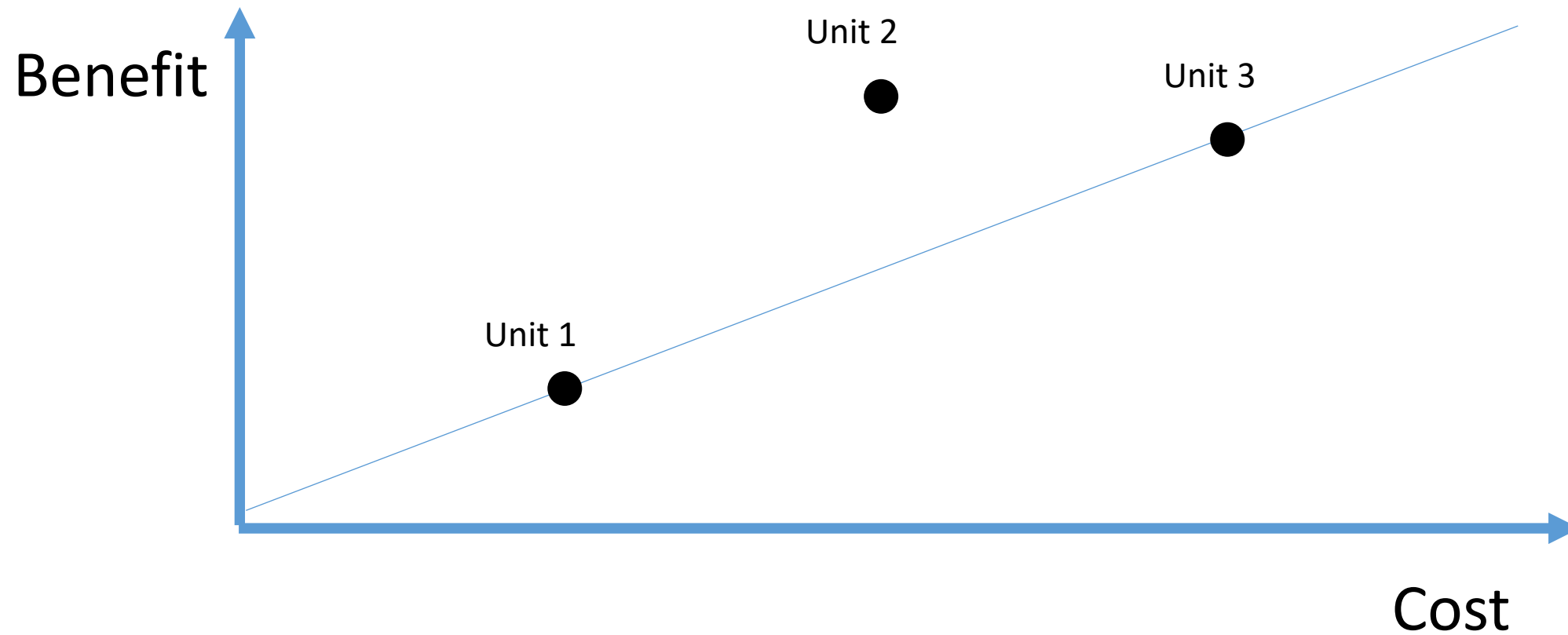
Benefit

Unit 3

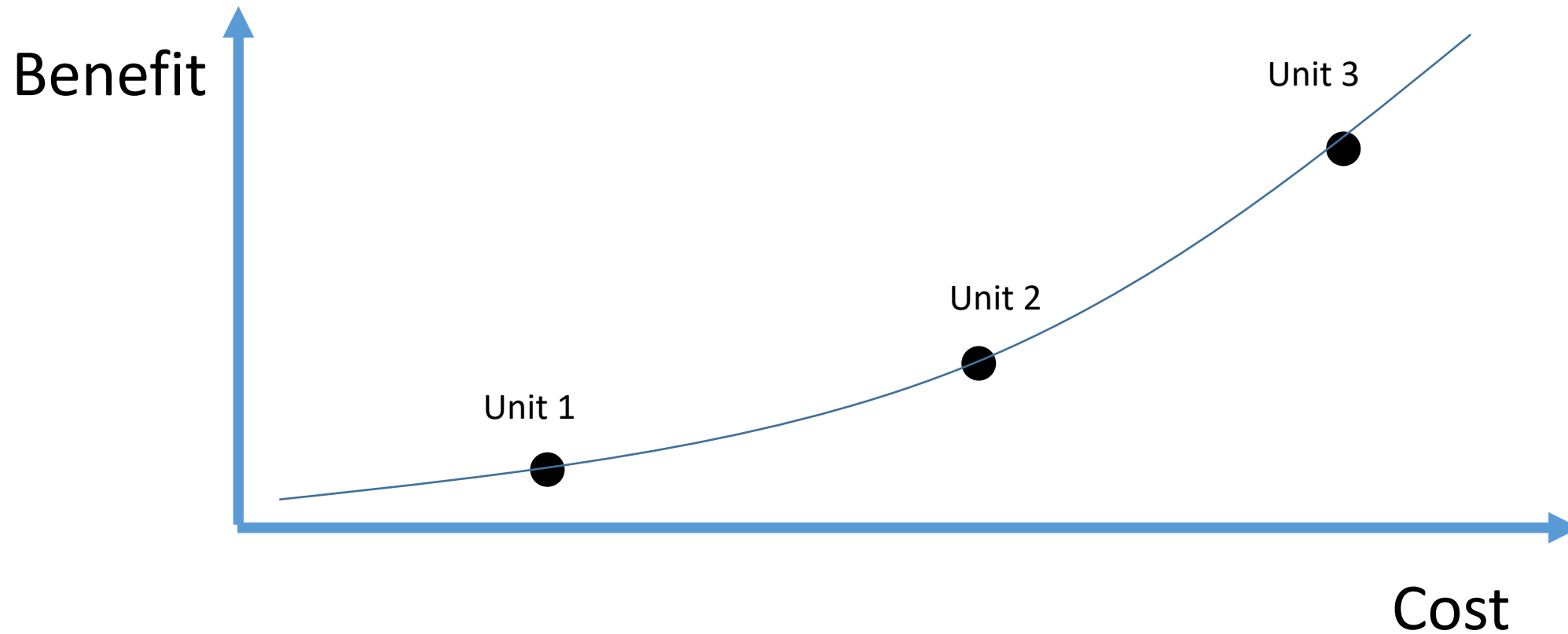Unit 2

Unit 1
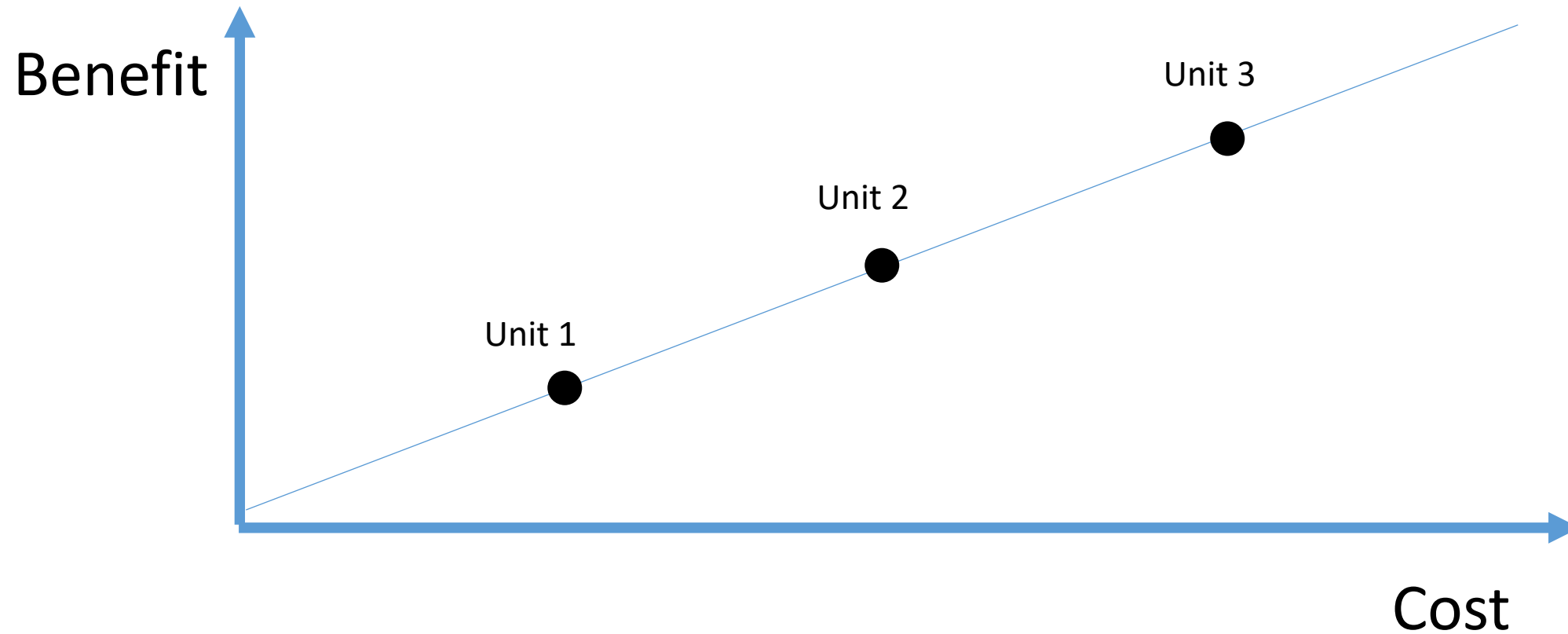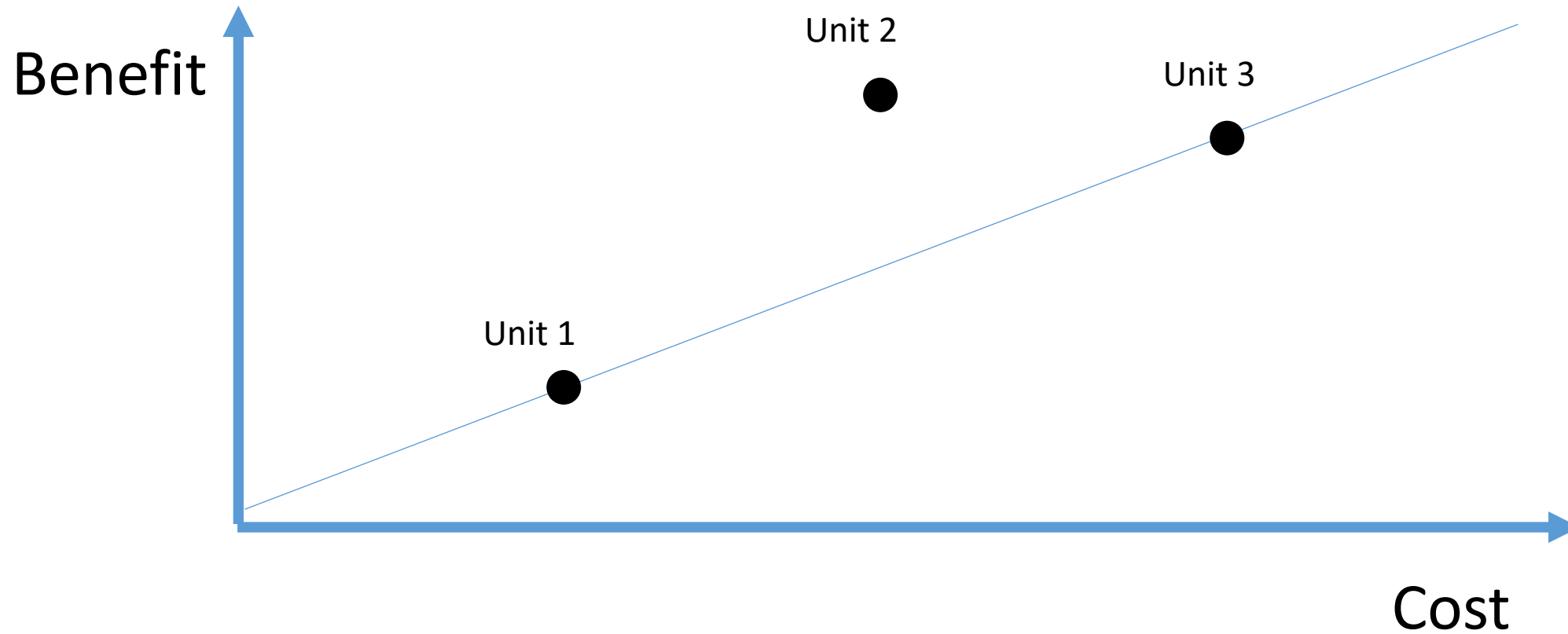
Cost

Why is this not good?

Less interesting decisions and diversity of gameplay

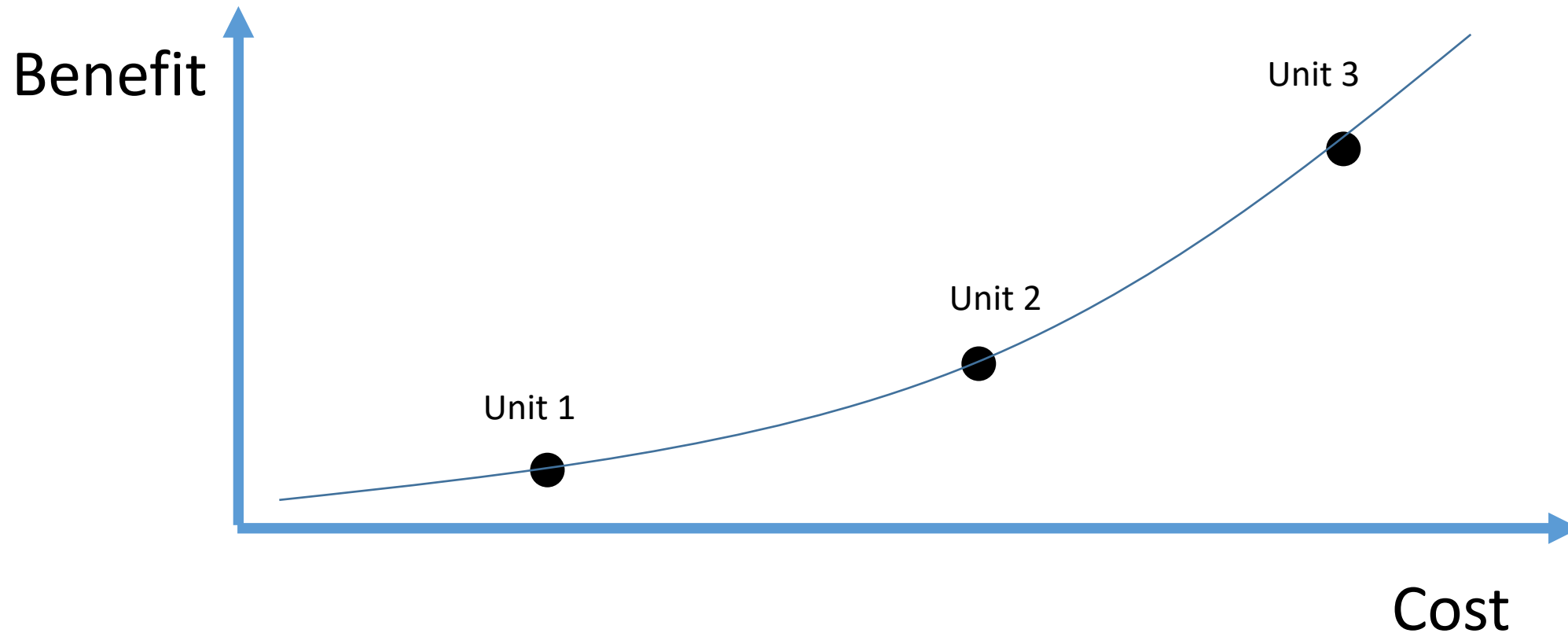# What exceptions to the rule?

Why sometimes a nonlinear curve?
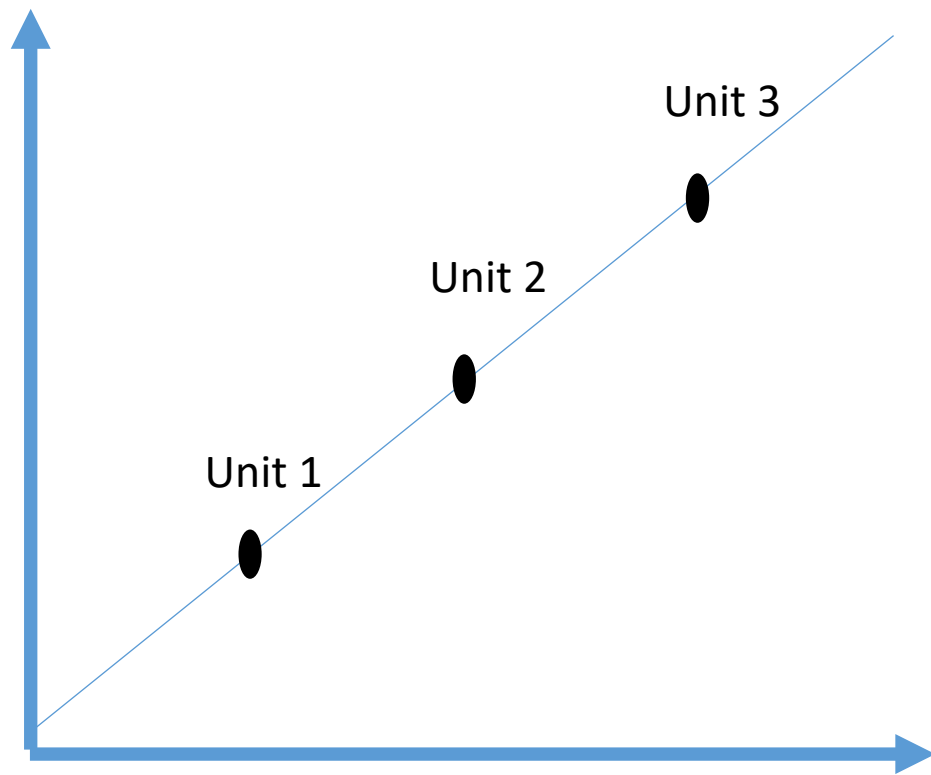
Why sometimes a nonlinear curve?

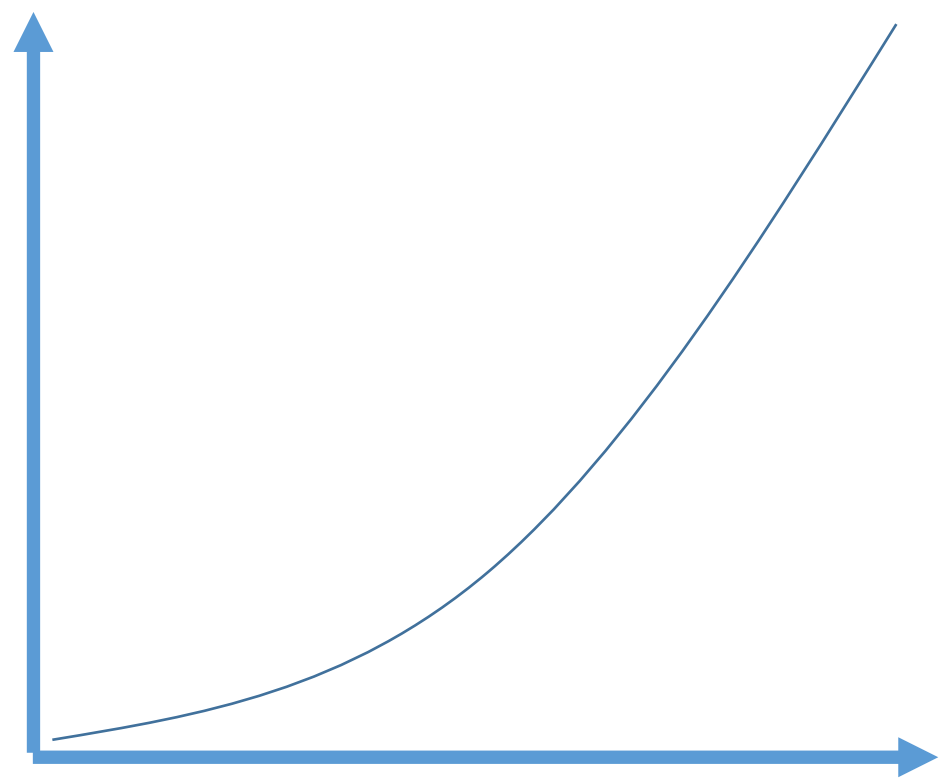Hearthstone: increasing mana pool => high-cost units only usable late in the game => must have higher benefit

Remember that these can and do coexist

Benefit

Unit 3
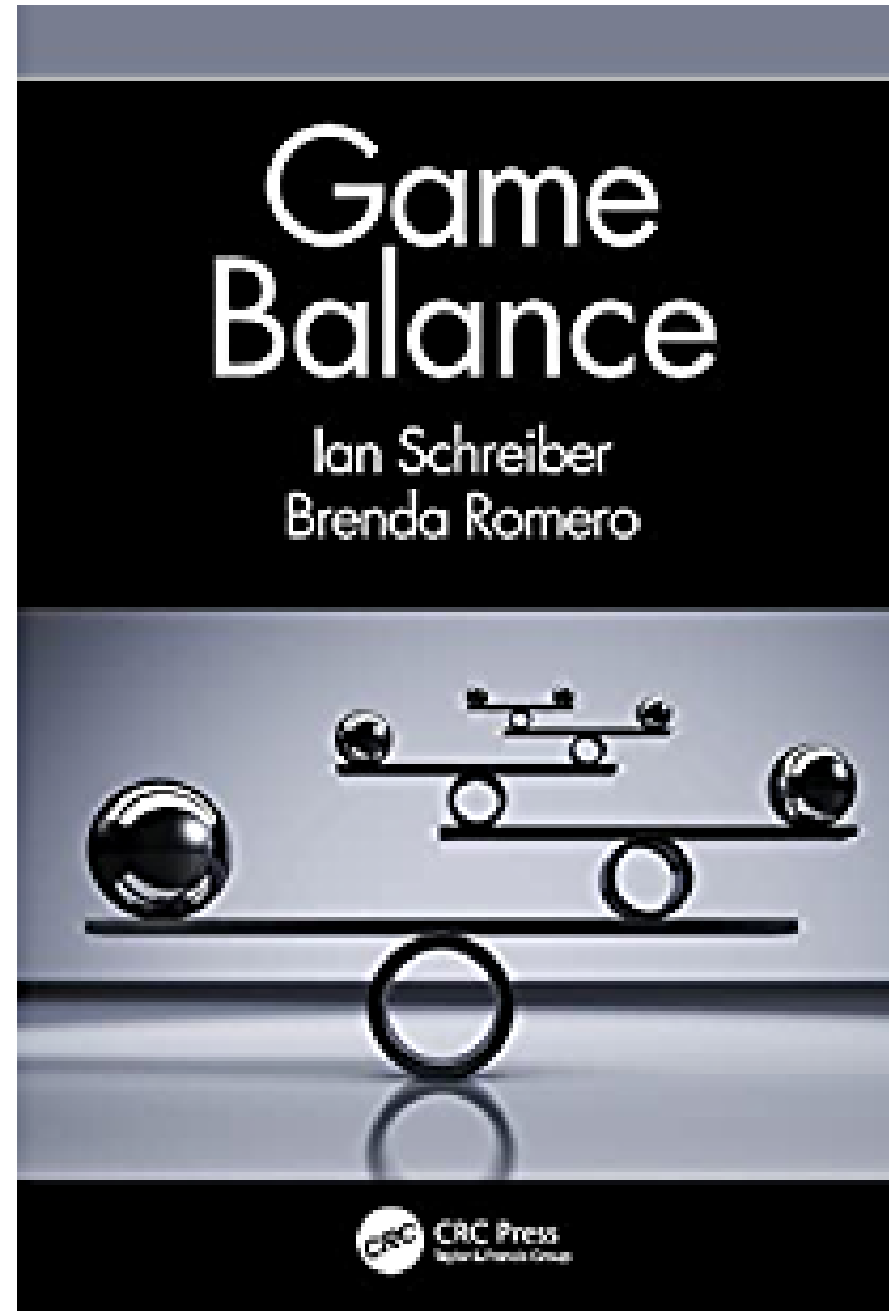
Unit 2

Unit 1

Cost

HP, DPS

Level

Balancing summary

- Math & spreadsheets are a good starting point
- Playtesting still needed, because not everything can be modeled
- Cost-benefit curves (balancing transitive relationships)
- Rock-paper scissors (balancing intransitive relationships)

Until next week: Clash Royale balancing

- Work through the Clash Royale balancing spreadsheet and/or Colab notebook at your own pace.

- You can also continue on the previous notebook, everyone makes as much progress as they can in this time.

- Before next week, also try to find time to play Walking Dead No Man's Land (complete 1-2 chapters)

Resources

Resources

http://www.gdcvault.com/play/1024272/Quest-for-the-Healthy-Metagame

https://gamedesignconcepts.wordpress.com/2009/08/20/level-16-game-balance/

http://gamebalanceconcepts.wordpress.com

http://rubycowgames.com/excel-and-google-docs-spreadsheet-tips-for-game-designers/

http://rubycowgames.com/excel-and-google-docs-spreadsheet-tips-for-game-designers-2/

http://www.gamasutra.com/view/news/36675/Opinion_Stop_Being_The_Useless_Designer__Excel_and_Formulas_.php

http://www.mitchzamara.com/essays/spreadsheet-functions-for-game-designers-part-1/

http://www.mitchzamara.com/essays/spreadsheet-functions-for-game-designers-part-2/

http://forums.rpgmakerweb.com/index.php?/topic/17393-excel-game-balance-workbook-data-sample/

http://iquilezles.org/www/articles/functions/functions.htm

https://www.quora.com/How-is-math-used-in-video-game-designing-and-programming