Game Biz

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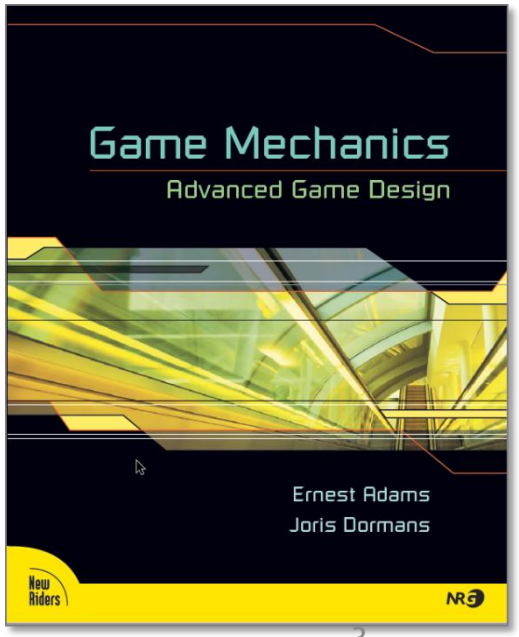
Economy & Balancing

- It's about the long term

What's an "Economy"

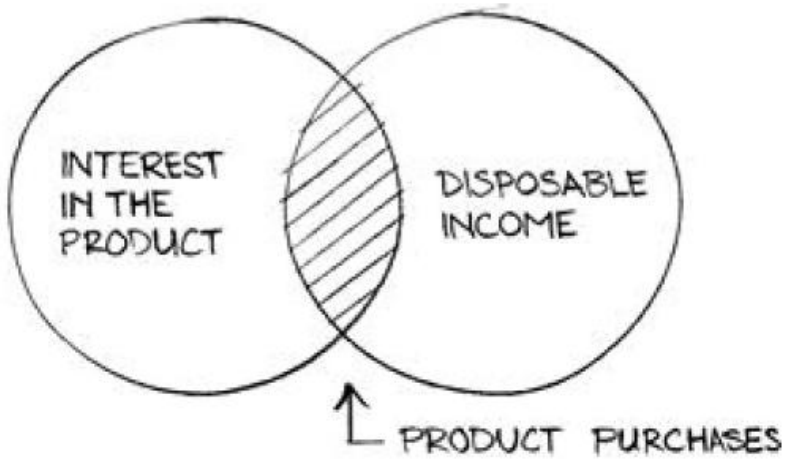
- *"In real life, an economy is a system in which resources are produced, consumed, and exchanged in quantifiable amounts. (…) In games, the internal economy can include all sorts of resources that are not part of a real-life economy - health, experience, and skill can be part of the economy just as easily as money, goods, and services." – Ernest Adams*

- Game Economy Design is ***not*** classical Economics
  - Concepts of economics, but more to do with strong Game Design.
  - Design of complex systems with emergent metagame.
  - Closed systems with self-contained ecosystems.
  - Understanding of programming and probabilities helps a lot.



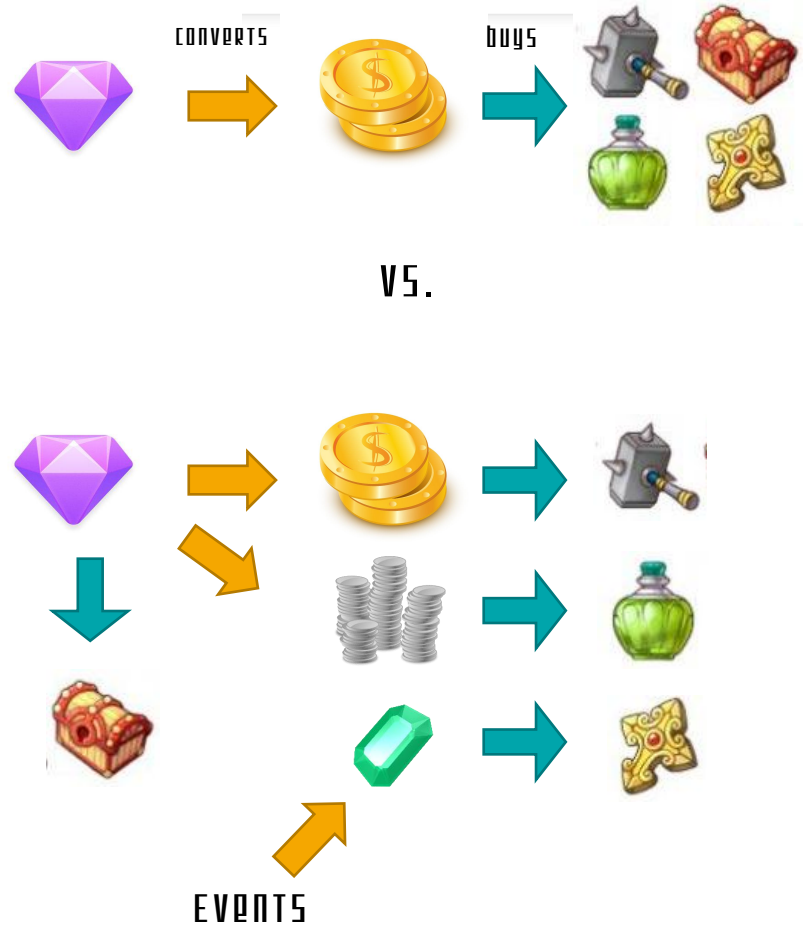
Goals of a game economy

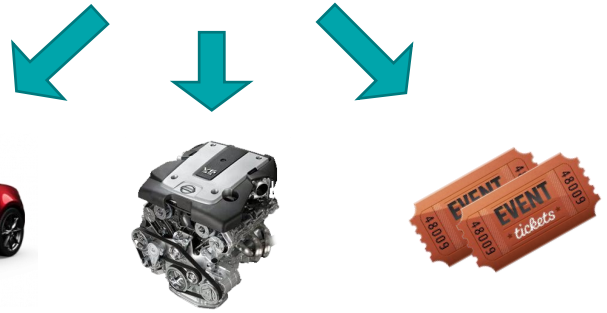
- *Fun* in the form of progression, loot and stats.
- Always deliver a *lot* of value, F2P or Premium.
  - Monetize on faster grind, *not to play the game*.
  - Gradually enable opportunities for extra purchases.
- ***Scale systems*** so that metagames and monetization can be relevant *long-term*.
- Avoid “paywalls” - failure to implement better systems or balance them.



Specialized Resources are ***easier to balance***

- Eliminate trade-off scenarios that result in more outliers;
  - Players who are either more powerful for finding “optimal strategies” users stuck in dead-ends.
- More prone to farming strategies.
- Less prone to Inflation across updates.
  - And its hard to fix Inflation later on updates, because few users will h a LOT.
  - Pricing for them will punish everybody.
- More Design control over the pace of progress.
  - Some resources may not even be convertible to Hard-Currency, keeping access under tight control of weekly Events.
- More Live Ops possibilities.





CARS

CAR UPGRADES

EVENT ENTRANCE

NEEDS TO MAKE COMPLEX INVESTMENT CHOICES

INVESTED IN THE OPTIMUM CAR AND OPTIMUM UPGRADES.

GAME BECOMES WAY TOO EASY AND NEVER CONVERTS.

INVESTED IN UPGRADES IN A WEAK CAR HE DIDN'T REALIZE WAS WEAK.

CANNOT COMPETE WITH MORE SAVVY PLAYERS, AND CHURNS FROM THE GAME.

DISCOVERS AN EVENT IN WEDNESDAYS GIVE WAY TOO MUCH GOLD, PAYING FOR ITS OWN ENTRANCE PLUS SOME.

HAS EVERYTHING TOP LEVEL, PLAYS 10 HOURS EVERY WEDNESDAY.

TIME-BASED FARMING.

CARS

CAR UPGRADES

EVENT ENTRANCE

"WHAT CAR TO BUY NEXT?"

"WHAT CAR AND PART TO UPGRADE?"

"HOW OFTEN DO I HAVE TO COME BACK?"

MUCH SIMPLER INVESTMENT CHOICES

BOUGHT A WEAK CAR, BUT IS NOW SAVING GOLD TO BUY A BETTER ONE.

UPGRADES NECESSARY TO COMPETE DOESN'T HARM HIS ABILITY TO MOVE TO THE NEXT CAR.

INVESTED IN OPTIMUM UPGRADES BUT IN THE WRONG CAR.

REMAIN COMPETITIVE ENOUGH TO GET A NEW CAR.

GETS BACK TO THE GAME VERY OFTEN TO GET TICKETS, BUT CAN ONLY PLAY ABOUT 3X MORE THAN A MORE CASUAL PLAYER.

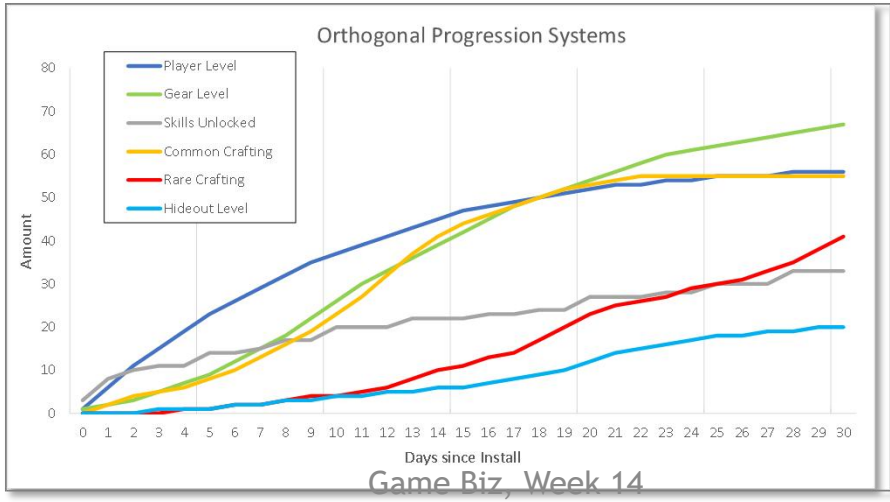
Shortcomings?

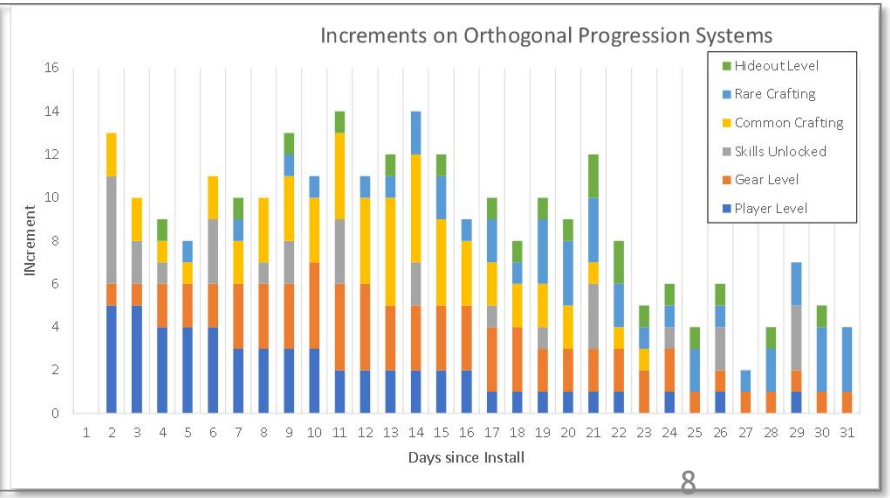
- *Feels* less intuitive and more complicated
  - Because the real-world economy works on a single currency enabling everything.
  - But really: is Investment a simple thing in the real world? ☺
- Much more challenging for UI developers.
- More overwhelming to new players.
  - Extra currencies need to be introduced slowly.
  - More tutorials.
- Less choice can alienate the really hard-core community.
  - So end-game, hard-core designs with combinatorial explosions should be devised if you expect a lot of players like that.

Design the Time for your Progression

- Games should be balanced around the *feeling of fulfillment and constant progress*.
  - See *Idle Games* for extreme but super-effective versions of how constant reward and progress can be addictive.
- *Purposefully design* the amount of Time players will need getting to progression milestones.
  - By amount of sessions, matches, days or time measure that makes sense for your game.
  - Orthogonal axis of progression advance at different paces to keep players interested.

Building	Base Cost	Base Income Rate
Cursor	15	0.1
Grandma	100	0.5
Farm	500	4
Factory	3,000	10
Mine	10,000	40
Shipment	40,000	100
Alchemy Lab	200,000	400
Portal	1,666,666	6,666
Time Machine	123,456,789	98,765
Antimatter Condenser	3,999,999,999	999,999
Prism	75,000,000,000	10,000,000



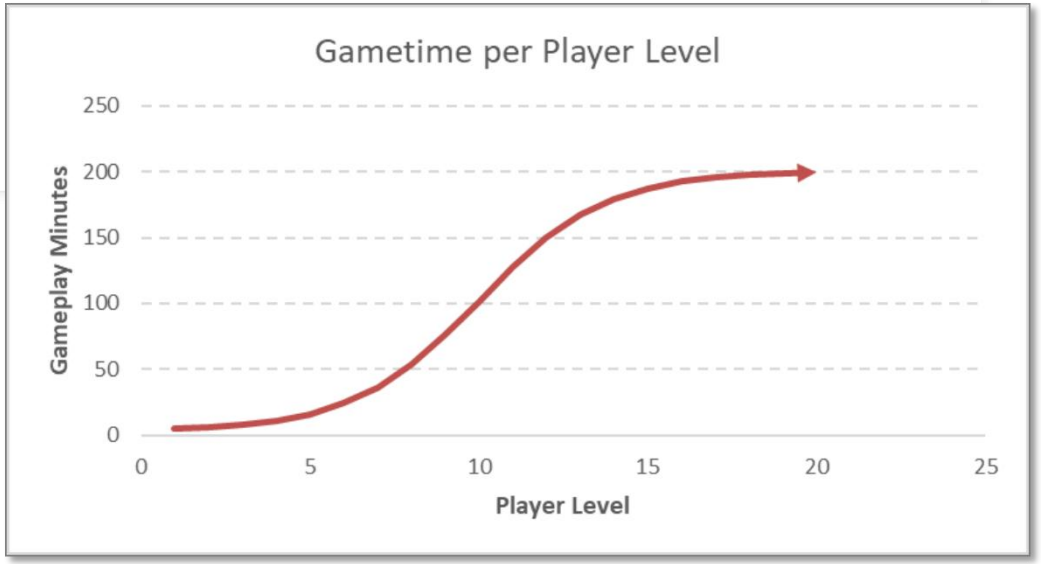


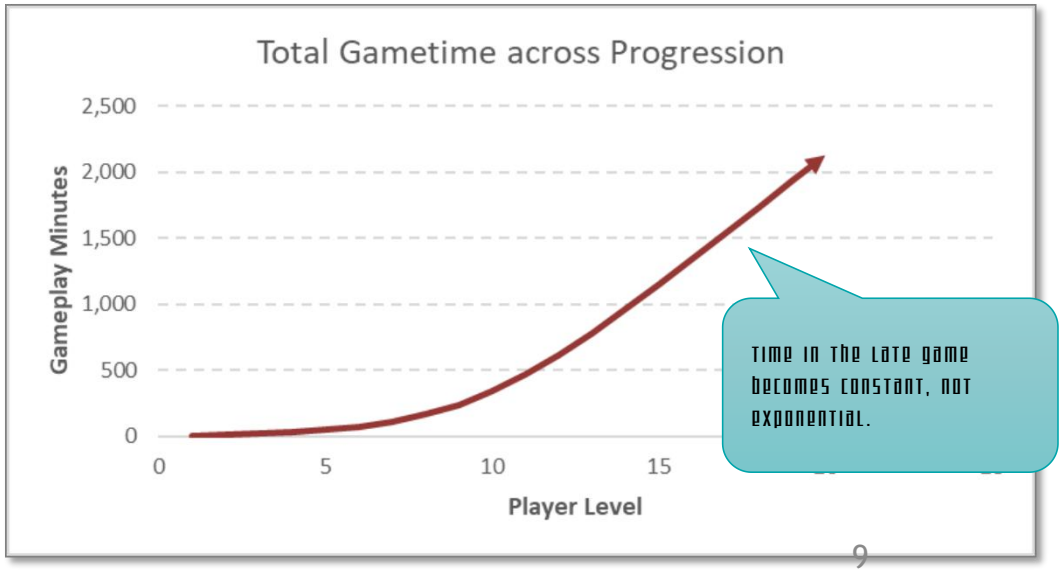
Sigmoid Functions

$$f(x) = \frac{L}{1 + e^{-k(x-x_0)}}$$

Idea: use a Sigmoid (Logistic) function to model increments in Time, which results in:

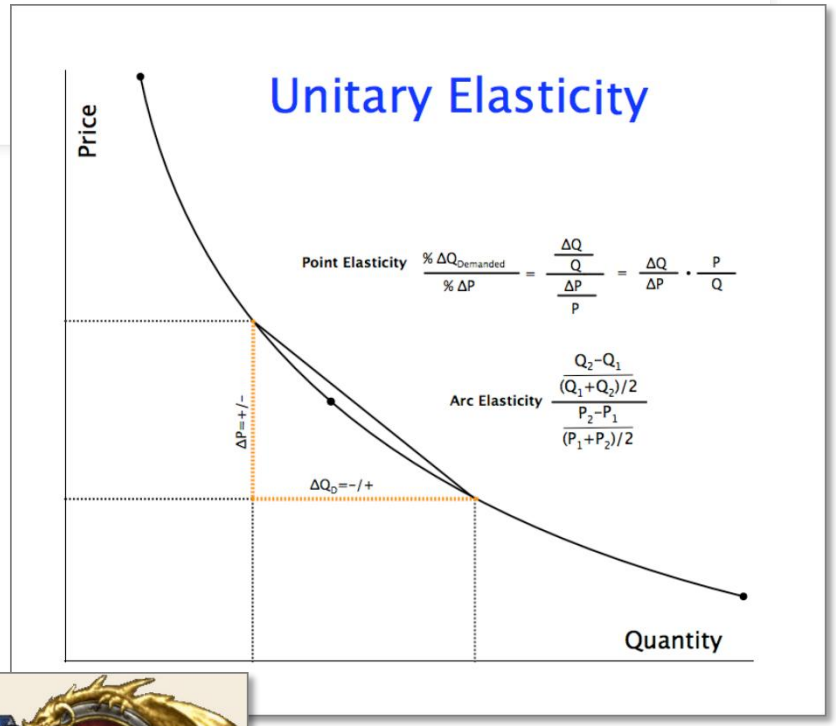
1. High-speed fulfillment in the beginning.
2. Ramp up of time in the middle.
3. Constant time in the advanced levels, so even elder players continue to reach new milestones at a relatively constant pace.





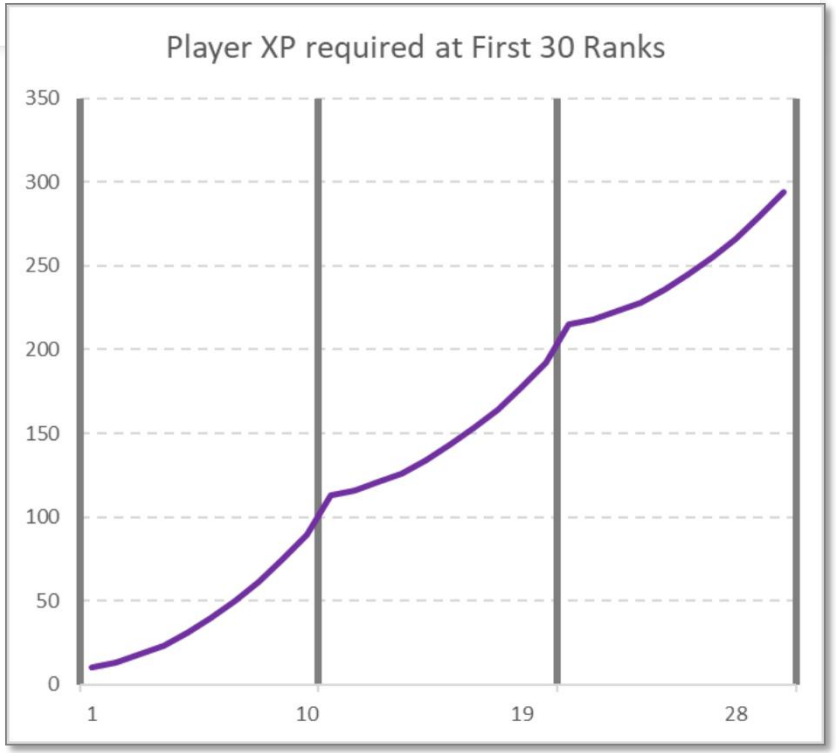
Cosmetic items are classic Economics.

- We're talking about **Cosmetic** effects:
  - Get an item not for its power, but for its looks.
- Ask players, do surveys.
- Classic price-elasticity problem.
  - Soft-launch / AB test to find the ones most coveted.
  - Evaluate charging more for them or making them harder to unlock.
- Watch how much players invest on them as a percentage of their *free* currency earned through Progression.
  - Not from purchased currency.
  - Players spending *free* currency in cosmetics will tell you how much time the item is worth.



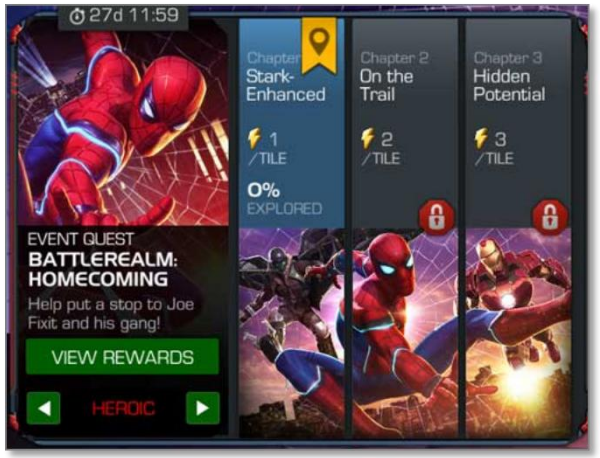
Tables in the game code over formulas

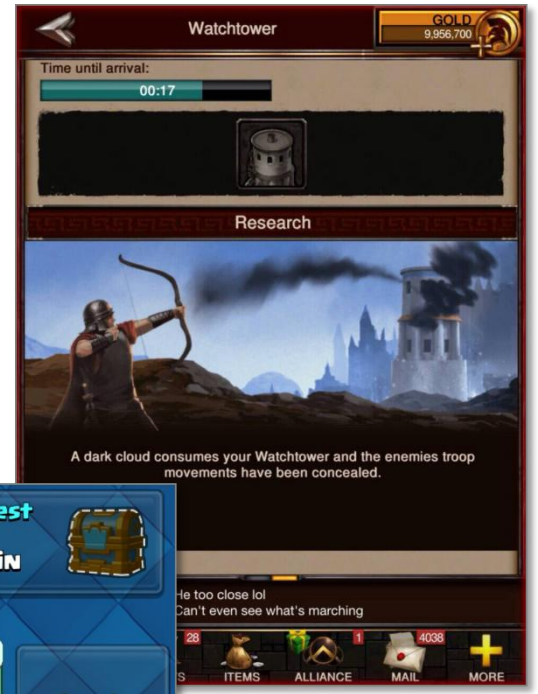
- Because you can do all kinds of fixes and special cases in your distributions.
- Example: level-up curve with spikes of cost at “milestones” in multiples of 10.
- **Easier to maintain for designers**, don’t need a programmer to just update the game database / config files.
- Shapes that are hard or impossible to do with simple formulas.
- (But for some specific cases that’s not possible, like Idle Games)



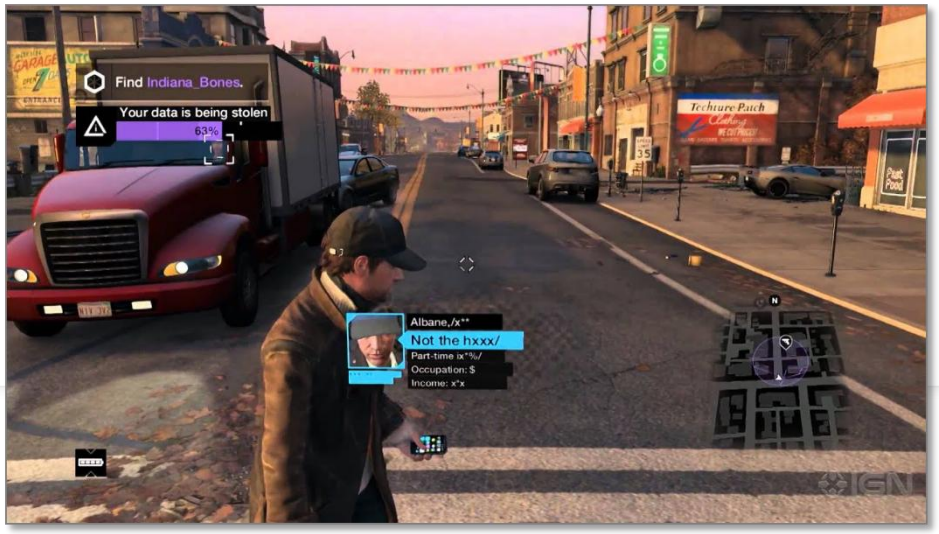
Appointment + Intermittent rewards

- Some possibilities:
  - Energy;
  - Delayed / ransomed rewards;
  - Time-limited access to game modes;
  - Random gifts;
  - Social systems.
- Mechanics around coming back often to optimize production
  - Heavy appeal towards Loss Aversion.
- Every 2 hours, have something that feels meaningful if the player comes back.
- Will be more effective *if the game loads fast*.





Probabilities over time

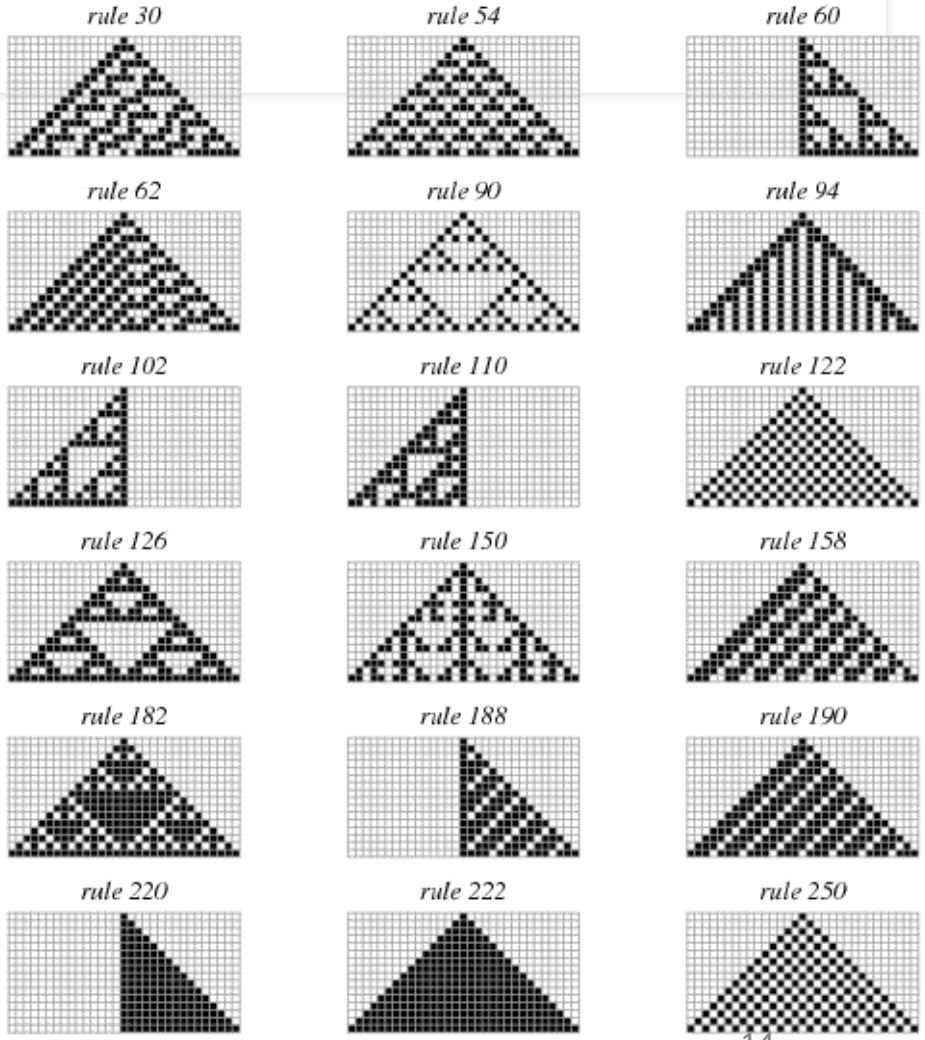


- Idea on how to sparse events and communications to still be intermittent but much more controlled than pure random.
- You can also use it for any intermittent events over time, such as “special bosses” or “nemesis attacks” or multiplayer interaction like in Watch Dogs 2.

Real-time Hours	Probability
1	0.82%
2	1.38%
3	2.34%
4	3.92%
5	6.50%
6	10.59%
7	16.80%
8	25.60%
9	36.97%
10	50.00%
11	63.03%
12	74.40%
13	83.20%
14	89.41%
15	93.50%
16	96.08%
17	97.66%
18	98.62%
19	99.18%
20	99.52%

Program simulations to assess economic flow.

- Why?
- The Cellular Automaton problem – *emergent systems*
  - A strictly deterministic system with emergent behavior can still lead to unpredictable results, no matter how good is the algebra.
- Games are *emergent systems*:
  - Even with very deterministic systems, it's very hard to "predict the metagame".
  - Simulating the actual progression and decision-making of thousands of players can reveal a lot of "blind spots" you wouldn't otherwise find until launching the game.
- If you have coding abilities.
  - Excel quickly gets very hard to scale.
  - Code will scale better with functions / classes / libraries / loops.



Inflation

- Bane of Live Ops

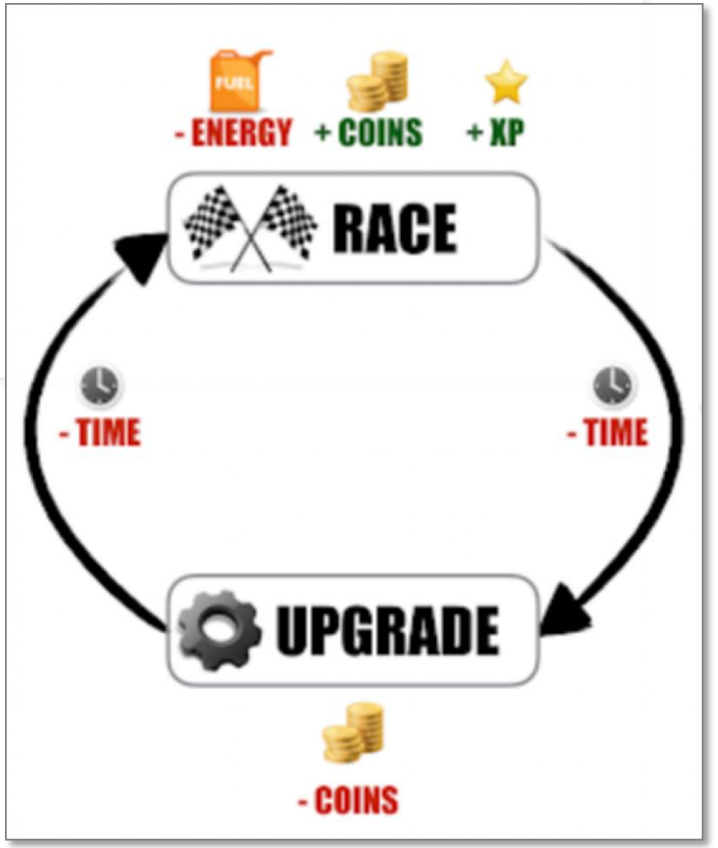
What is Inflation?

- Classic economics: the decline of purchasing power of a currency over time.
- Sustained inflation occurs when a nation's money supply growth outpaces economic growth.
- Many reasons why this happens: demand-pull, government debt, export + monetary policy, other factors.
- A whole theory and field of study to explain it: *monetarism*.

Price Levels in Brazil, 1980 to 1997	
Year	Consumer Price Index
1980	4
1981	8
1982	16
1983	38
1984	111
1985	362
1986	895
1987	2,940
1988	21,435
1989	328,113
1990	100,000,000
1991	500,000,000
1992	5,600,000,000
1993	113,600,000,000
1994	2,472,400,000,000
1995	4,104,400,000,000
1996	4,751,200,000,000
1997	5,080,300,000,000

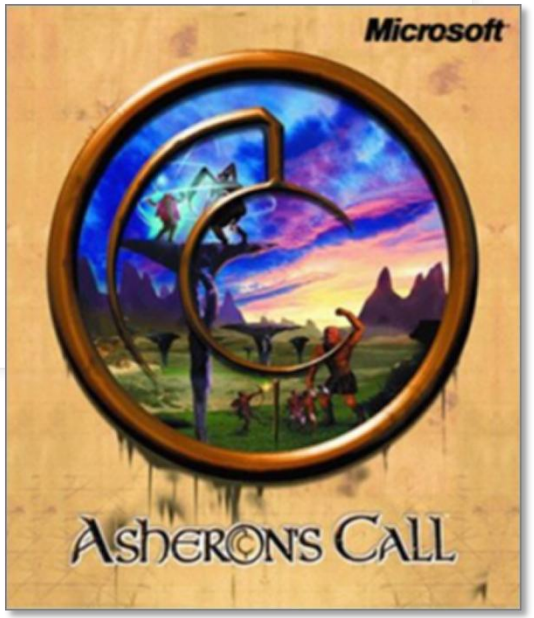
Source: IMF Financial Statistics

Inflation within Game Systems



- Similar concept in which game features "print" resources faster than the economy ***sinks*** it.
- Players accumulate without being able to spend.
  - Easy case: end-game of old-school RPGs.
- But very different dynamics:
  - *No "invisible hand"*: both supply and demand are controlled by features that can be *balanced* and manipulated. Invalidates classic economics formulas (except Trading)
  - Not supply/demand between individuals, but *systems **to*** individuals.
  - *Resources are not necessarily interchangeable* - unlike the real world, it is impossible to trade an Iron ingot for a Potion if the game doesn't allow it.

Vulnerability



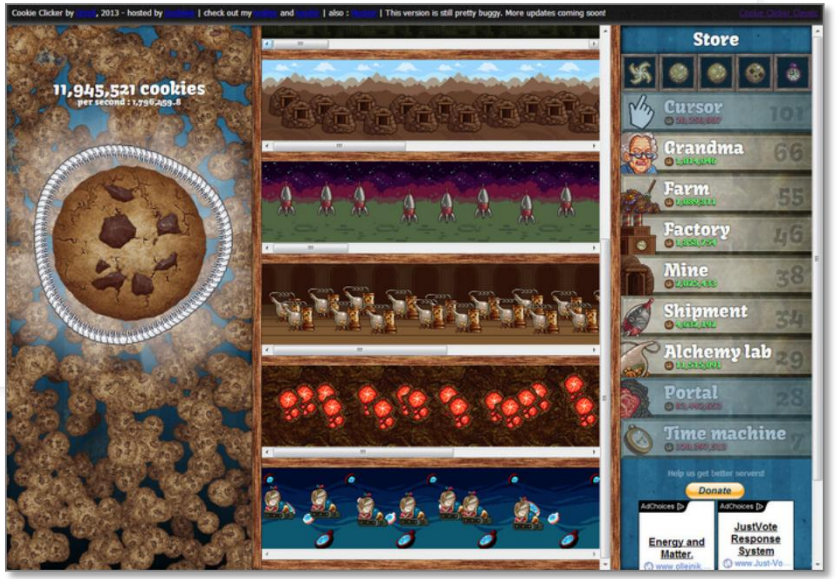
- Video game economies are particularly susceptible to hyperinflation.
  - Not dependent on a *physical* currency or a commodity that can be finite and regulated.
  - Production is by definition *limitless*: gaining coins for killing monsters, rewards for goals.
  - *Each player is printing money*.
- The more freedom the game gives to players to explore and consume the game their own way, *the harder it is to control Inflation*.
  - Metagames are *emergent systems*, hard to predict by definition.
- Multiply this by potentially millions of players.
  - And, like in the real-world financial markets, a portion of the player base will begin optimizing techniques to create currency fast: *farming*.

Inflation over Time

- Players **will grind**: ***never*** underestimate their passion.
- Inflating resources can devalue the entire system around it.
  - Why get more Gold rewards if you can't spend you current Gold?
  - You stop coming back for daily rewards that are mostly Gold-based.
- Launching new content that cost an inflated currency will have end-game users immediately buying all of it, defeating all your hard work to keep players coming back.
- Tip: **Start your systems expensive:**
  - Everyone loves a discount, no one likes a price increase

Not just Currency!

- A fundamental concept that can affect all stats-based and resource systems:
  - Transient: Items / consumables
  - Permanent: XP and Power (creep)
- **Permanent or temporary inflation**: a time-limited event can flood the economy with a certain resource *on purpose*.
- *Not necessarily bad* -inflation can be by *design*,
  - Like in idle games (Cookie Clicker, AdVenture Capitalist)
  - Or to keep players investing, like keep training troops for gold.
- It becomes bad when it **damages and undermines** your design goals for your systems.
  - For Permanent resources, that becomes *really bad*.



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Sources vs. Sinks

- The challenge is how to balance the pace in which players generate resources from Sources vs. the pace in which they spend resources in Sink features.
- Over time imbalances accumulate
  - Sometimes *exponentially* so.
  - The longer a user plays an unbalanced system, the more resources they accumulate without being able to sink it.
- Imbalances in amount of Sources vs. fewer features to Sink creates opportunities for Inflation to creep up.
- Example: Hay Day

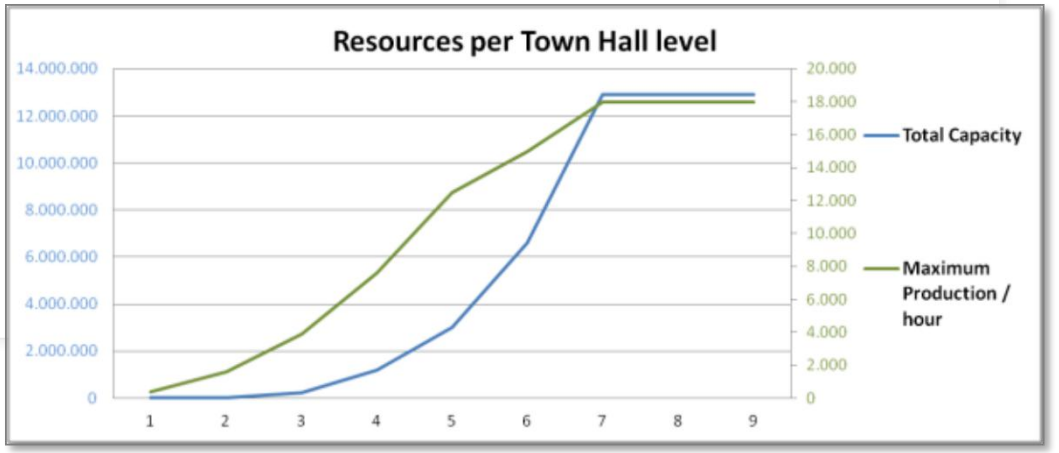
One-time Sinks - Permanent acquisitions

- Buildings, Level-ups, decorations, cosmetics - can sink a large amount at once, but:
  - Usually don't scale long-term without a permanent content-production machine in the dev team.
  - End-game content cost absurd amount of currency in an attempt to sink them all at once. Bad player perception.
- Vanity is easy for game balance as it doesn't affect stats.
  - But if you only have 2 artists, how do you keep this train rolling?
  - Could make them deeper: upgrade cosmetics, level system within them, like Love Nikki
- But how much permanent content can your game support?
  - More permanents = more work, more inventory space

Recurrent Sinks - Consumables

- Consumables / currencies intrinsic to the game loop will keep sinking, but require adequate systems design from the ground up.
  - Potions, troops, revives, seeds, salaries.
  - Very high up-front cost to introduce a new system like that, requiring design, programming, UX, QA, producer approval - it's in the core loop after all, **can easily affect fun**.
- Optional / quality-of-life consumables:
  - Boosts, power ups, helpers, time-limited multipliers.
  - Potential side effects: do these boosts induce inflation in another part of the economy?
  - May be compartmentalized in new *optional loops*, which will require supporting art / assets to make it work, like puzzle pieces in Hay Day.

Resource Caps



- **Max cap** on specific resources help designers avoid explosive scenarios.
  - Also work as an engagement mechanic using loss aversion.
- But doesn't replace good balance: a badly balanced systems, even if capped, can also feel cheesy unfair and detract from **fun**.
  - Imagine keep earning Gold but can't accumulate anymore of it.
  - Like keep finding ammo in a shooter while the weapon is full. Doesn't it feel like a "waste" if this happens too often?
  - Remember Loss aversion...

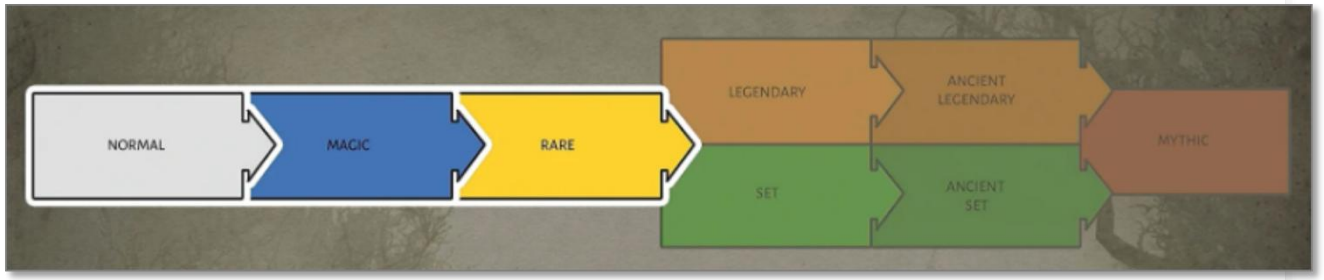
Caps on Trading

- *Uncapped prices*:
  - Market reacts fast to Inflation
  - But detracts from new players experience: end-game users with lots of cash will price items at levels newbies can't afford.
  - *Potential churn*.
- *Capped prices*:
  - Make the economy more accessible to everyone
  - But then it may detract from the experience of the end-game user
  - Maybe parallel markets in the interwebs.

Deflation

- *Very rare* event in gaming, seemingly happened at New World.
- Opposite of inflation: players cannot "create" currency fast enough compared to the needs of sinks.
  - When not enough currency is maintained in an economic system, ***items*** start to drastically lose value
  - No one has money to spend as the money itself gains value.
- Raw resources that go into crafting will always be needed, but the medium of exchange became a problem.
  - These Raw resources slide in price since the game came out
  - Not because they've become easier to get but because money has become more valuable than the raw resources themselves.
  - Even worse for high-end crafting.
- High tax burden for crafting, homeownership, and armor repair.
- Happened a few times in history, and people may resort to bartering. But game systems might limit this meta-solution.
- Solutions:
  1. Pump more Gold in the economy via rewards. But not easy to do, as pumping too much may sling the economy in *inflation*.
  2. Remove "tax" burden, like on repairs.
  3. Trade items for Gold in fixed ratios at NPC vendors, establishing baselines.

Content Inflation



- Content inflation is the process by which a certain type of core Content, though initially more rare or exclusive, becomes more accessible and less valuable to players over time
  - Thereby reducing its initial value.
  - Rare items, artifacts, legendary, etc.
- Monetization that relies on specific Content will decline as content inflate.
  - These economies requires a **content deprecation cycle**.
  - Managing Content Inflation means managing the value of game content throughout the lifetime of the game.
- Largest banes of any game developer, as it's the main challenge of how to sustain long-term monetization.

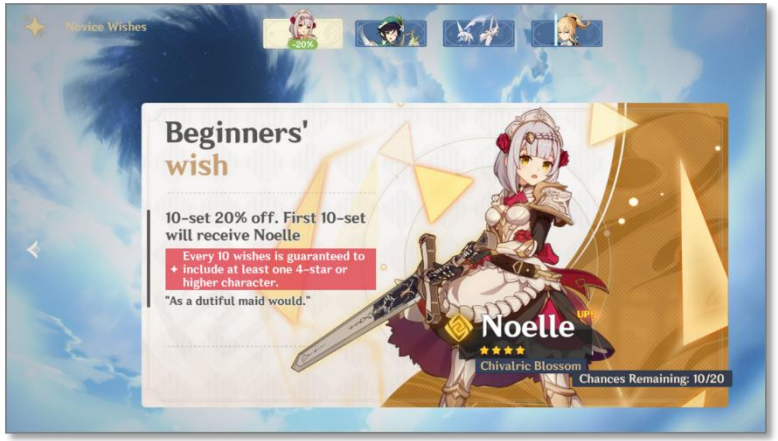
Content Deprecation Cycle

- The idea behind a CDC is that content's value is tied to how expensive the source of that content is.
- The more expensive (in money or time of grind) the source of content is, the more valuable that content will be.
- As the same content is given out in less expensive sources, its value declines.
- New content released in more expensive sources will have a higher value.

Event Final Rewards	Highest Value
Gacha Super Rare Drop	Highest Value
Bundle Sale Content	High Value
Gacha Regular Drop	High Value
Store Content	Medium Value
Event Lower Reward	Medium Value
Loot Drop	Low Value

Content Deprecation Cycle

- **Cannibalization** occurs when content that is lower on the CDC is as valuable as content higher on the CDC.
- Example in Genshin Impact:
  - 4-Star Weapons can be found through Wishes or forging.
  - If they dropped from Bosses, loot farming becomes relatively more attractive than purchasing Wishes
  - So players would replace Wishes for farming Bosses. Bosses would be effectively cannibalizing revenue.
  - Players would still spend on Wishes - 5-Star Weapons still maintain their high value. But monetization is delayed.
- But over time, 4-Star Weapons become necessary for end game users to remain competitive.
  - How to give players the opportunity to get them more often reducing cannibalization risk?



Content Deprecation Cycle

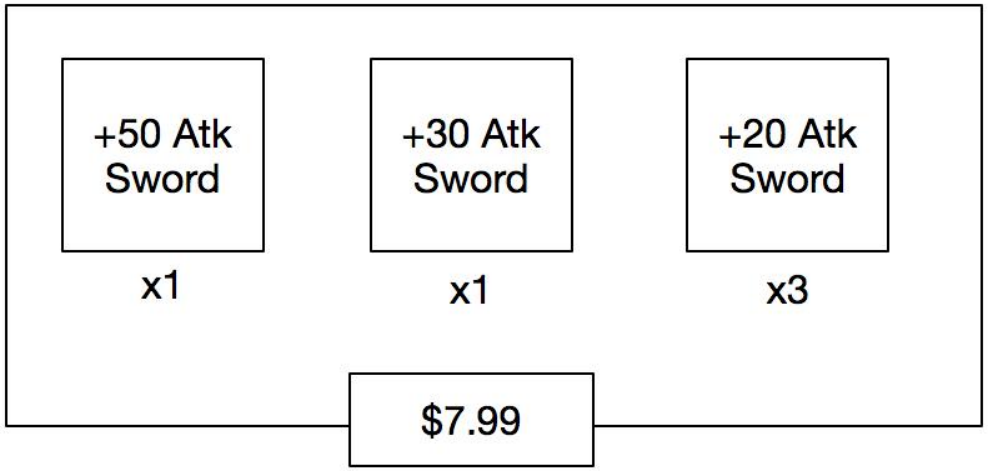
- Resources given throughout the CDC will only cannibalize sales if the quantities of such resources earned through grinding rivals quantities earned through purchases.
- But cannibalization can be by design if the game systems keep introducing higher level items in the top of the CDC
- In Match-3 Games:
  - Boosters that clear more of the board are objectively more valuable than Boosters that clear less of the board.
  - Cannibalization occurs in Match-3 Games when the better boosters are given out too freely - or when lesser boosters so frequent that Players don't feel compelled to spend on better boosters.
  - But over time, giving away better boosters become a necessity to keep players engaged.

A new treadmill instead of repairing the old one.

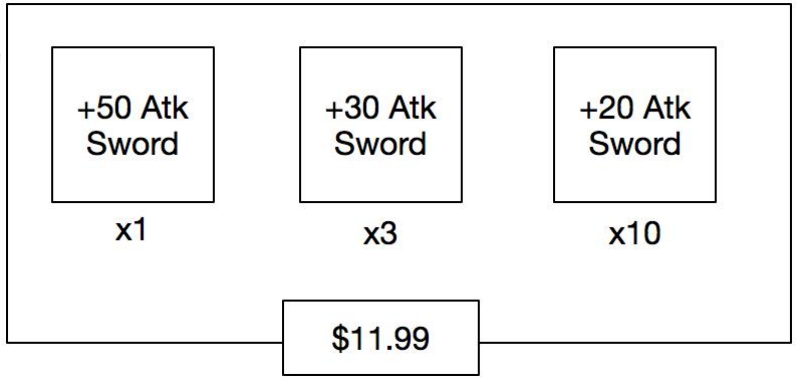
- Over time, **a content treadmill becomes harder to maintain.**
  - The gap between average players and high spenders will increase as the game gets older.
  - Very difficult for Game Developers to figure out who to design and balance content for.
  - Gets to the point where either you are focusing solely on your spenders and your non-spenders drop off, or you cater too much to free players and your monetization suffers.
- Easier to cease creating content for an existing system and instead **create a new system to transition your spenders to**.
  - Doing so frees a lot of design space to keep engaging higher spenders.
  - On the other hand, the CDC funnel old system's content to average players.
- *Clash of Clans*: second base was introduced with a separate economy
  - Progress from the first Base didn't affect a lot of what was happening
  - Because of that, the second base allowed Supercell to control the content experience for spenders and non-spenders alike.

Designing Bundles with Content Inflation

- Consider you have in your shop a selection of Swords:
  - +40 Atk for $5, which sells 150 units a day for a total revenue of $750 a day.
  - +30 Atk for $2, which sells 125 units a day for a total revenue of $250 a day
  - +20 Atk for $1, which sells 50 units a day for a total revenue of $50.
- You want to introduce a bundle pack with a +50 Atk Sword. which would sell for $10 by itself due to inflation
  - We know that by the time players are powerful enough to use a +50 weapon, those +20 and +30 varieties are dropping as Boss loot.
  - +20/+30 are devaluing as attack power inflates. We priced +40 non-linearly at $5 because of this.
  - For players even further down progression, we can price the new +50 also non-linearly at $10.
- Say we put together a bundle like in this figure.
- This bundle may increase sales due to delivering almost double value - $15 sold for $8
  - But also has the potential to cannibalize future sales of +50
  - Players will always want to buy this pack instead of the +50 Atk Sword alone.
  - You incur the risk of leaving money on the table.



Designing Bundles with Content Inflation



- Instead, let's sell the bundle at a price *above* the best item and increase its value with *more of the lower-tier* items instead.
  - They bring less total revenue per day anyway.
- In this case, a $26 value bundle is sold for $12, also nearly double value.
  - The difference is that this pack cannibalizes **the lower-tier items instead**
  - There are a lot of +30 Atk and +20 Atk Swords, and their combined price ($16) is more than the price of the bundle.
- As players progress, the +50 Sword is still valuable for a lot more time than the +30 Atk and +20 versions.
  - They only accounted for $300 a day, while the +50 is probably selling for $1000 a day due to its higher price.
- In Game of War, many bundles would have a ton of crafting content that was much less valuable when compared to other items.
  - Yet, adding this lower value content to a bundle made the bundle value *look and feel* much better.
  - When you know the value of a certain content is getting obsolete, don't be afraid to squeeze more money out of it by bundling with more relevant content players care more about.

Balancing Random Systems

Expected Value and more

Expected Value

- EV of an Item = **(Probability of the item) * (Quantity)**
- For example, consider the following Loot design:

Item	Amount	Weight	Probability	Expected Value
Hard-Currency	5	100	19.96%	1.00
Hard-Currency	10	20	3.99%	0.40
Soft-Currency	500	200	39.92%	199.6
Soft-Currency	1,000	70	13.97%	139.7
Soft-Currency	2,000	50	9.98%	199.6
Iron Sword	1	50	9.98%	0.10
Crystal Sword	1	10	2.00%	0.02
Adamantium Sword	1	1	0.20%	0.002

Expected Value

- As consecutive Chests are opened, you can just sum the Expected Values to Project what the player will earn on average:
- You can use the EV to balance how much to charge for a Chest – or how fast to give it for free.
- You can use the same concept for any other random system, like Enemy loot, probability to get Daily Bonuses, probability to get specific Daily Quests, etc.

	Total Expected Value		
Item	1 Draw	2 Draws	3 Draws
Hard-Currency	1.4	2.8	4.2
Soft-Currency	538.9	1077.8	1616.8
Iron Sword	0.10	0.20	0.30
Crystal Sword	0.02	0.04	0.06
Adamantium Sword	0.002	0.004	0.006

Price per Draw	$ 0.50
Free Chests per Day playing	10
Days of play per week	4

Item	Draws to Get 1 unit	Dollars to Get 1 unit	Days to get 1 unit for Free	Weeks to get 1 unit for free
Iron Sword	10.0	5.0	1.0	0.3
Crystal Sword	50.1	25.1	5.0	1.3
Adamantium Sword	501.0	250.5	50.1	12.5

Be careful with Averages!

- Obsessing only with the "right" expected value can blind you for how the feature is actually distributed and *fun* for players to use.

Item	Amount	Weight	Probability	Expected Value
Hard-Currency	5	100	19.96%	1.00
Hard-Currency	10	20	3.99%	0.40
Soft-Currency	500	200	39.92%	199.6
Soft-Currency	1,000	70	13.97%	139.7
Soft-Currency	2,000	50	9.98%	199.6
Iron Sword	1	50	9.98%	0.10
Crystal Sword	1	10	2.00%	0.02
Adamantium Sword	1	1	0.20%	0.002

Item	Total Expected Value		
	1 Draw	2 Draws	3 Draws
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Crystal Sword	0.02	0.04	0.06
Adamantium Sword	0.002	0.004	0.006

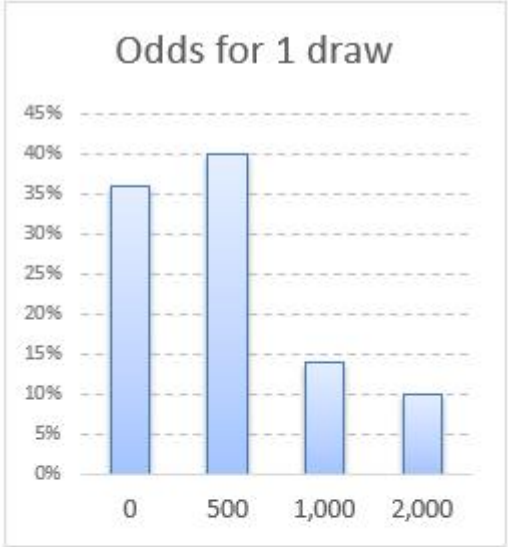
VS.

Item	Amount	Weight	Probability	Expected Value
Hard-Currency	15	25	9.28%	1.39
Soft-Currency	100	200	74.24%	74.2
Soft-Currency	15,000	8.4	3.12%	467.7
Iron Sword	1	30	11.14%	0.11
Crystal Sword	1	5	1.86%	0.02
Adamantium Sword	1	1	0.37%	0.004

Item	Total Expected Value		
	1 Draw	2 Draws	3 Draws
Hard-Currency	1.4	2.8	4.2
Soft-Currency	541.9	1083.9	1625.8
Iron Sword	0.11	0.22	0.33
Crystal Sword	0.02	0.04	0.06
Adamantium Sword	0.004	0.007	0.011

Balance around outliers created by random systems.

- Every geometric random system like the loot chest described before generates **outliers** - users who get too much or too little, out of sheer chance.
- Consider the odds of how much Soft-Currency our Chest gives in 1 draw:



1 Draw

Soft Currency Received	Probability
0	36%
500	40%
1,000	14%
2,000	10%

- As we calculate the probable amount of Soft-Currency for drawing **2** times, the shape of our distribution starts to change.

1 Draw

Soft Currency Received	Probability
0	36%
500	40%
1,000	14%
2,000	10%

2 Draws

Soft Currency Received	Initial Probability	Conditional Probability	Amount Earned in 2 Draws
0	36%	13.1%	0
500	40%	14.4%	500
1,000	14%	5.0%	1,000
2,000	10%	3.6%	2,000
0	36%	14.4%	500
500	40%	15.9%	1,000
1,000	14%	5.6%	1,500
2,000	10%	4.0%	2,500
0	36%	5.0%	1,000
500	40%	5.6%	1,500
1,000	14%	2.0%	2,000
2,000	10%	1.4%	3,000
0	36%	3.6%	2,000
500	40%	4.0%	2,500
1,000	14%	1.4%	3,000
2,000	10%	1.0%	4,000

Outcomes at the 2nd draw *given that* the first draw was 0

Outcomes at the 2nd draw *given that* the first draw was 500

Outcomes at the 2nd draw *given that* the first draw was 1000

Outcomes at the 2nd draw *given that* the first draw was 2000

- Continue to evaluate drawing 3 times...

A pattern is emerging in the joint probability as we draw more...

2 Draws

Soft Currency Received	Initial Probability	Conditional Probability	Earned in 2 Draws
0	36%	13.1%	0
500	40%	14.4%	500
1,000	14%	5.0%	1,000
2,000	10%	3.6%	2,000
0	36%	14.4%	500
500	40%	15.9%	1,000
1,000	14%	5.6%	1,500
2,000	10%	4.0%	2,500
0	36%	5.0%	1,000
500	40%	5.6%	1,500
1,000	14%	2.0%	2,000
2,000	10%	1.4%	3,000
0	36%	3.6%	2,000
500	40%	4.0%	2,500
1,000	14%	1.4%	3,000
2,000	10%	1.0%	4,000

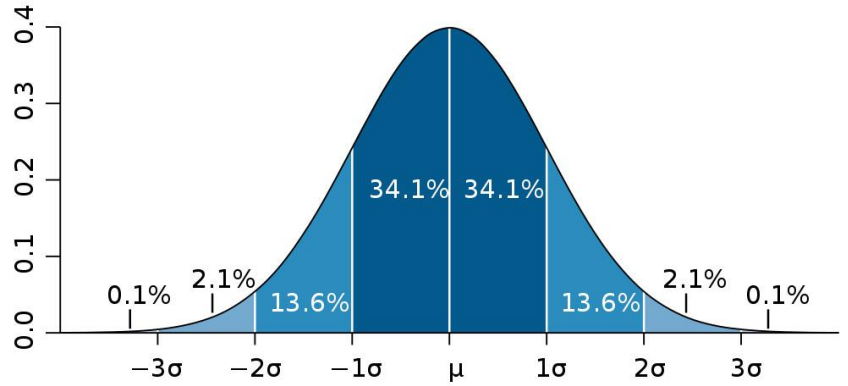
3 Draws

Soft Currency Received	Initial Probability	Conditional Probability	Earned in 3 Draws	
0	36%	4.72%	0	Outcomes at the 3rd draw *given that* the 1st draw was 0 and the 2nd was 0
500	40%	5.21%	500	
1,000	14%	1.82%	1,000	
2,000	10%	1.30%	2,000	
0	36%	5.21%	500	Outcomes at the 3rd draw *given that* the 1st draw was 0 and the 2nd was 500
500	40%	5.76%	1,000	
1,000	14%	2.02%	1,500	
2,000	10%	1.44%	2,500	
0	36%	1.82%	1,000	Outcomes at the 3rd draw *given that* the 1st draw was 0 and the 2nd was 1000
500	40%	2.02%	1,500	
1,000	14%	0.71%	2,000	
2,000	10%	0.50%	3,000	
0	36%	1.30%	2,000	Outcomes at the 3rd draw *given that* the 1st draw was 0 and the 2nd was 2000
500	40%	1.44%	2,500	
1,000	14%	0.50%	3,000	
2,000	10%	0.36%	4,000	
0	36%	5.21%	500	Outcomes at the 3rd draw *given that* the 1st draw was 500 and the 2nd was 0
500	40%	5.76%	1,000	
1,000	14%	2.02%	1,500	
2,000	10%	1.44%	2,500	
0	36%	5.76%	1,000	Outcomes at the 3rd draw *given that* the 1st draw was 500 and the 2nd was 500
500	40%	6.36%	1,500	
1,000	14%	2.23%	2,000	
2,000	10%	1.59%	3,000	

...etc...

Soft Currency Received	Draws 1	2	3	4	5	6	7	8	9	10
0	36%	13%	5%	2%	1%	0%	0%	0%	0%	0%
500	40%	29%	16%	7%	3%	1%	1%	0%	0%	0%
1,000	14%	26%	23%	15%	9%	5%	2%	1%	0%	0%
1,500	0%	11%	18%	18%	14%	9%	5%	3%	1%	1%
2,000	10%	9%	13%	16%	15%	12%	9%	5%	3%	2%
2,500	0%	8%	11%	13%	14%	13%	11%	8%	6%	4%
3,000	0%	3%	8%	11%	13%	13%	12%	10%	8%	6%
3,500	0%	0%	3%	8%	11%	13%	13%	12%	10%	8%
4,000	0%	1%	2%	4%	8%	11%	12%	12%	11%	9%
4,500	0%	0%	1%	3%	5%	8%	10%	11%	11%	10%
5,000	0%	0%	0%	2%	3%	6%	8%	10%	11%	11%
5,500	0%	0%	0%	1%	2%	4%	6%	8%	10%	10%
6,000	0%	0%	0%	0%	1%	2%	4%	6%	8%	9%
6,500	0%	0%	0%	0%	1%	1%	3%	5%	6%	8%
7,000	0%	0%	0%	0%	0%	1%	2%	3%	5%	7%
7,500	0%	0%	0%	0%	0%	0%	1%	2%	3%	5%
8,000	0%	0%	0%	0%	0%	0%	1%	1%	2%	4%
8,500	0%	0%	0%	0%	0%	0%	0%	1%	2%	3%
9,000	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%
9,500	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%
10,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
10,500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11,500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12,500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
13,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
13,500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
14,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

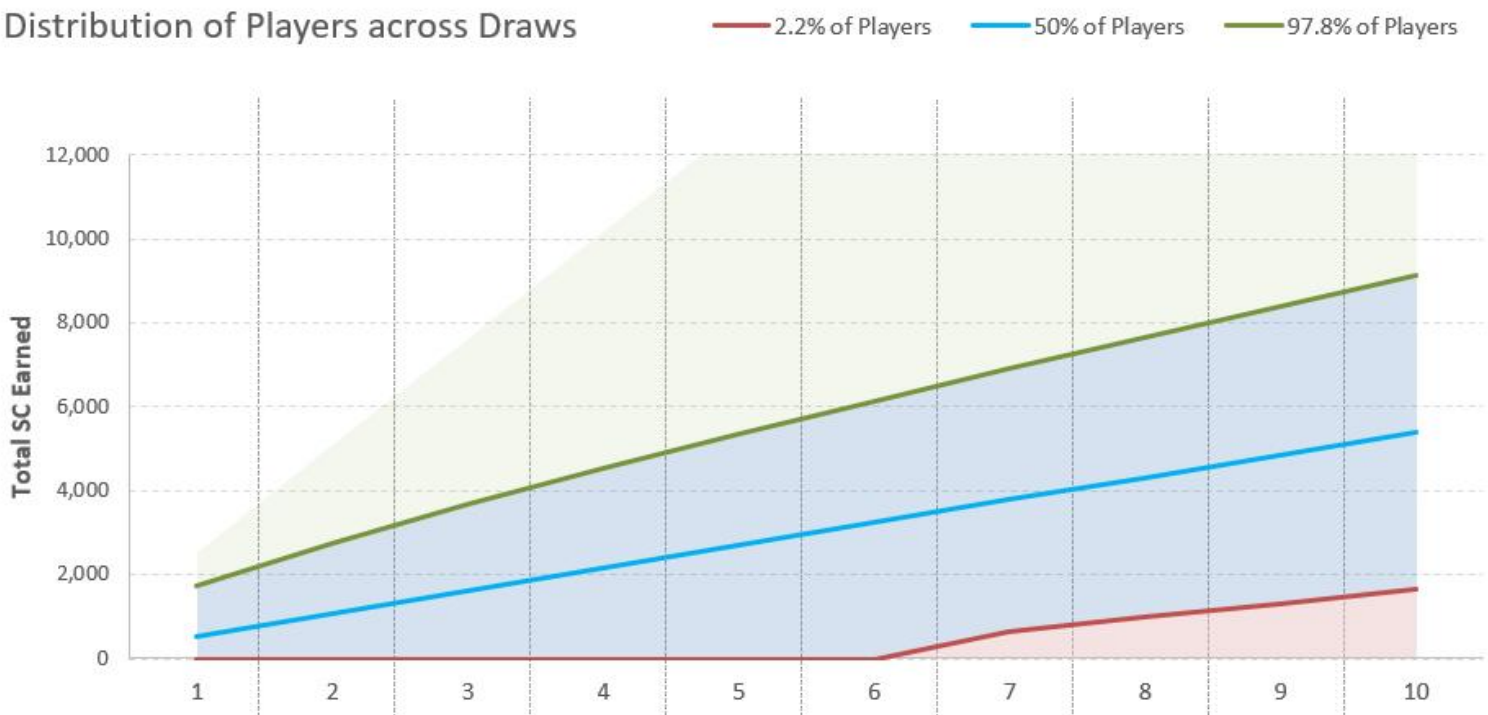
Normal Distribution!



- Geometrical systems *tend* to become Normal Distributions over time.
- We can then use the properties of Normal Distributions to evaluate our potential outliers.

Calculate how much SC your outliers have.

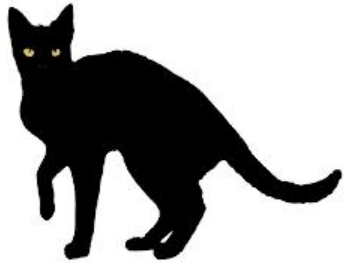
- Lucky players are > +2 Standard Deviations away from the mean.
- Unlucky ones, < -2 Standard Deviations.
- As they draw more Chests, the spread between them increases.



Mean	540	1,080	1,620	2,160	2,700	3,240	3,780	4,320	4,860	5,400
Maximum that the *bottom* 2.2% have	0	0	0	0	0	0	657	981	1,318	1,667
Minimum that the **top** 2.2% have	1,721	2,749	3,665	4,521	5,340	6,132	6,903	7,659	8,402	9,133
"Unlucky" Mean	0	0	0	0	0	0	443	449	898	1,346
"Lucky" Mean	2,000	3,263	4,360	5,346	5,959	7,004	7,575	8,588	9,154	10,164

How do you prevent too many outliers?

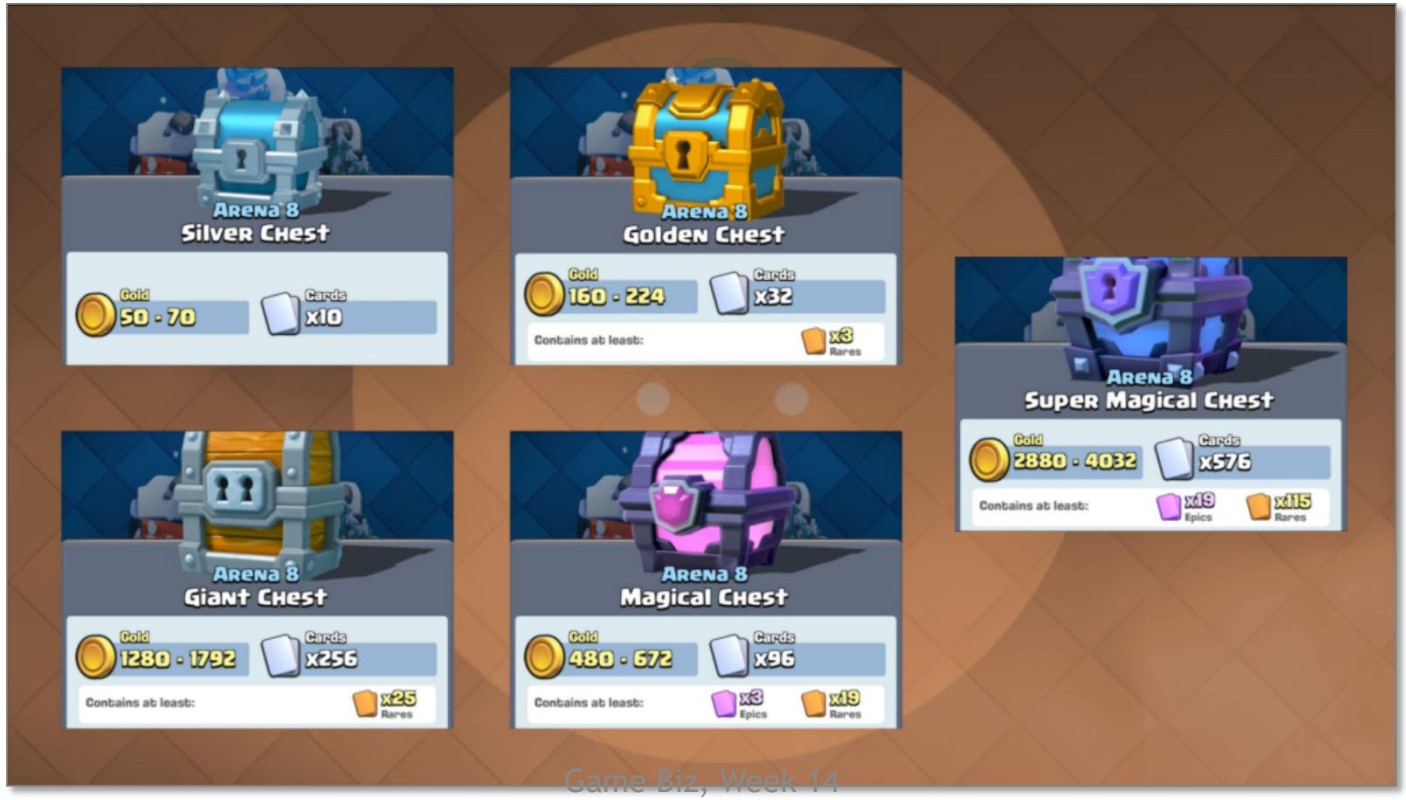
- Some players *will* be more lucky or unlucky.
  - Without this knowledge, when designing a loot system, you might think: “it’s OK if they get lucky”.
  - But what if they get **really unlucky**?
  - Generally, the amount of “lucky” players are the same as the “unlucky” ones!



- This is a big problem if some of your ***paying users*** are in these populations.
  - They are either spending less than they should, or they will churn away in frustration.
- How does your game treat lottery outliers?
  - Is it balanced for them too?
  - Can it still be fun if you only have the SC the “unlucky” population got?
  - Do you have systems to prevent them from becoming too powerful or to churn away?

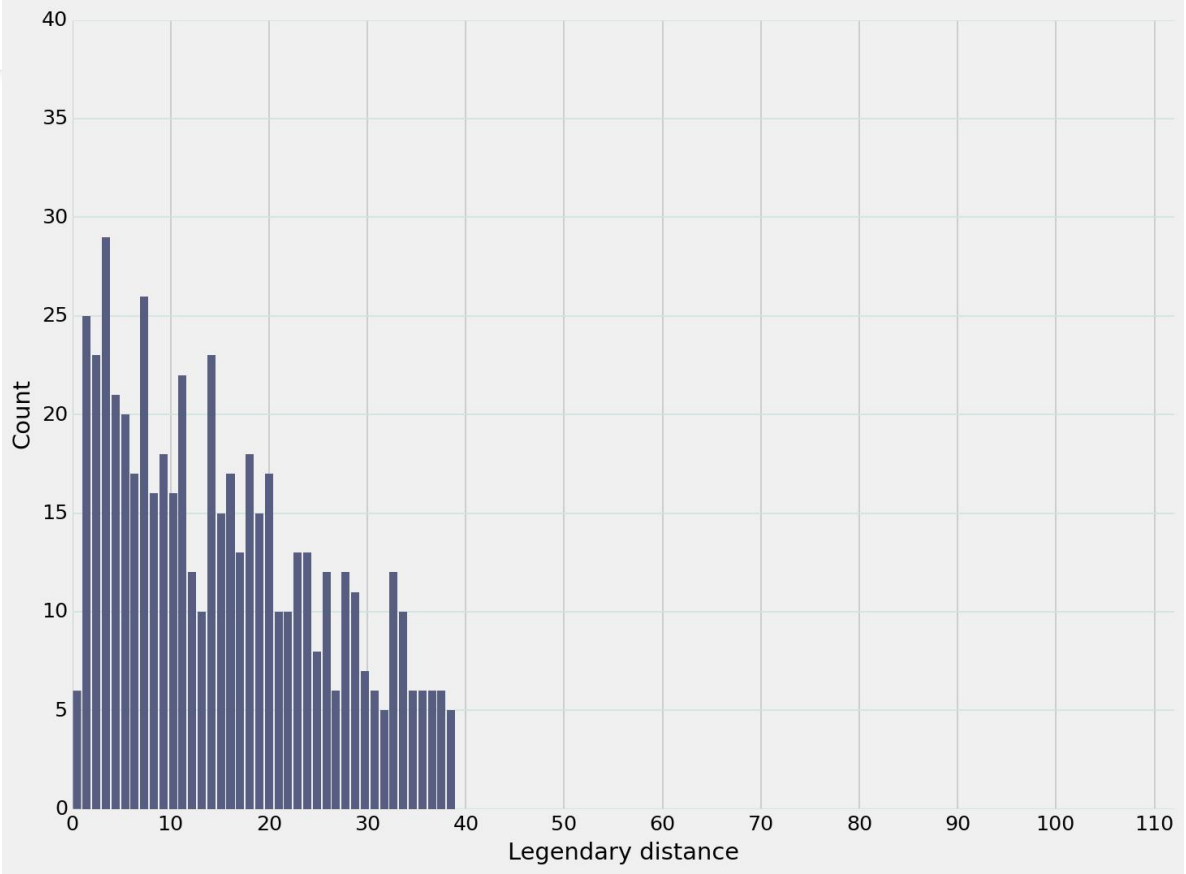
Guarantee certain draws / rarities

- Like in Clash Royale, a certain amount of Rare or better cards is guaranteed, and a certain range of resources too.



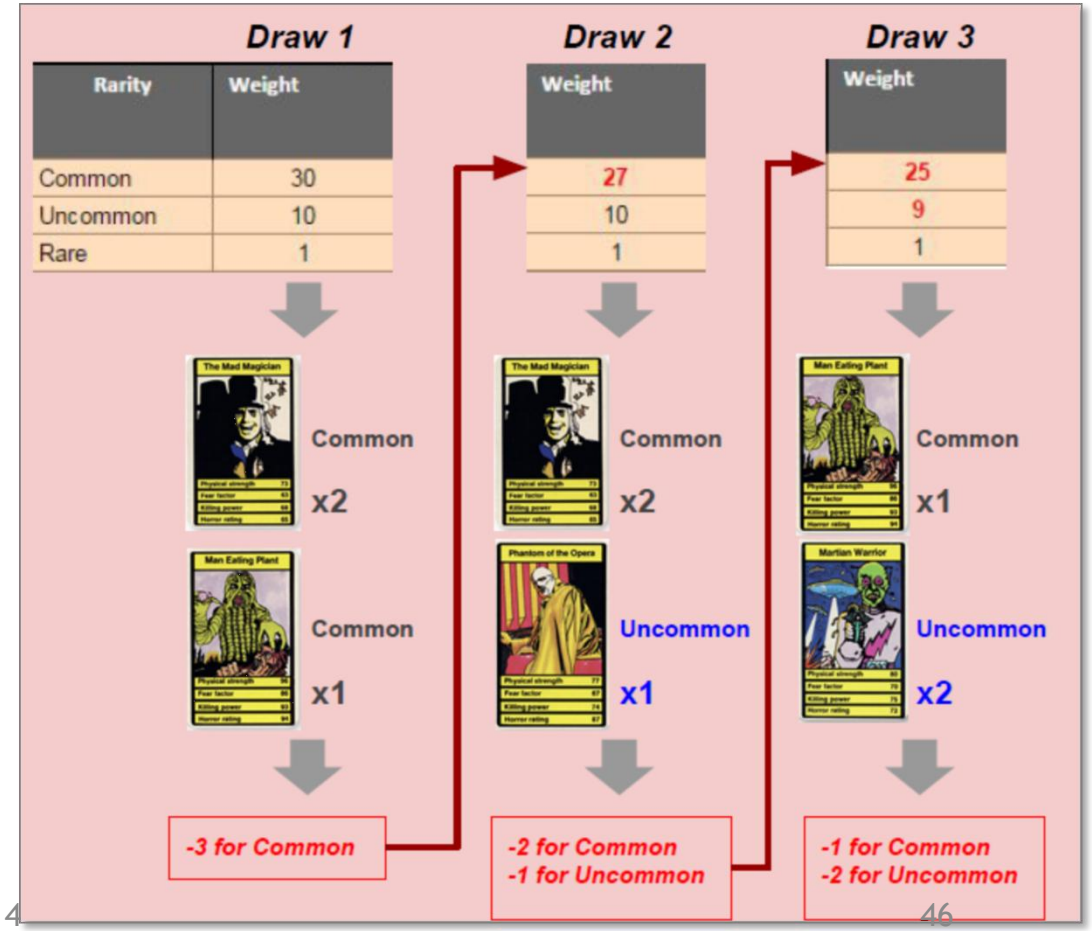
Pity timers

- Like in Hearthstone, if you open too many packs without a Legendary, your odds begin to change until you find one.



Consider a “bag of marbles” system

- Hypergeometrical, like a deck of cards.
  - Every time you draw a card of a certain rarity, -1 weight.
  - Once all weights are zero, restart.
- More certainty for the player.
  - On long-term, guarantees less outliers on the bottom.
- Problem of determinism.
  - Possibility of resetting the loot table with a certain condition of finding a rare item



EV + variance model works for different resources.

- Example for reaching a certain Player Level:
- Users won't accumulate XP in the same pace – some will play more days, others will play less.