Using Math to Balance Temporum Cards

By Thomas Tang

Your game's got a bunch of cards/troops/abilities/buildings/anything. You can make sure they're all balanced by using math. I'll use Temporum as my case study.

What’s Temporum

This is a board game by Donald X. Vaccarino, the person who also created the board game Dominion. In Temporum you draw cards and use them to gain power in different time periods.

There are 30 different cards in the deck (and 30 more in the expansion). With math, it is guaranteed that all of the cards are usable.

Temporum Simplified

To use math on a game, you want to first simplify it as much as possible. Here's Temporum at its bare bones:

You start the game with 2 cards for free. Then on your turn, your choices are: draw 2 cards; play a card from your hand; or score a card from your hand

When you play a card, it gives you money and you follow its instructions

When you score a card, it costs money and gives you +Crowns

First player to get to 30 crowns wins

Using Math

There are 3 resources in the game: cards, money, and crowns.

The math for them goes: 1 card = $4 = 1 crown

Drawing 2 cards (one of your options on your turn) is 2x4 = +$8

Drawing 2 cards, playing a card, and scoring a card all require 1 turn. Since a card is worth $4, drawing 2 cards is worth $8, which means 1 turn is worth $8. Which also means playing a card and scoring a card are both worth $8.

An Actual Example

When you play a card, it costs 1 turn ($8) and 1 card ($4) from your hand. This means there's an opportunity cost of $12 when you play a card. To make up for that, a card must give you $12 when played (if it doesn't, then playing the card is a bad idea because you can always choose to do something else).

Artist gives $8 when you play it, and it draws a card (+$4), and that totals to $12.

An Actual Example

What if you decide to score Artist instead? That also costs 1 turn ($8) and 1 card ($4). Then you have the pay the cost on the bottom row; for Artist, that is $4. Which means scoring it is an opportunity cost of $16.

If you do score Artist, you get 4 crowns for it. 4x4 = $16, meaning you get exactly what you pay for.

An Actual Example

This math is used for all cards in the game. All cards do $12 when played (give or take), and their scoring formulas are all perfectly balanced.

Trinket gives $4 and lets you play another card. The ability to play a card is worth $8, and that totals to $12.

And if you compare Trinket's scoring formula to Artist, you're paying $4 more for 1 more crown, exactly perfect.

Pop Quiz

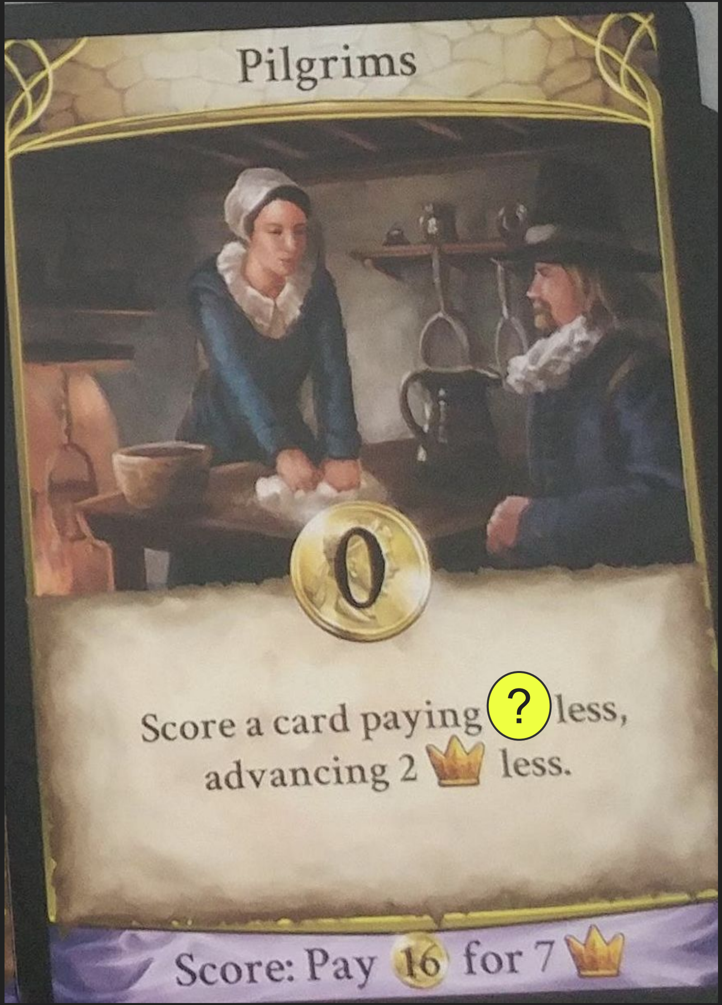
Here's a way math can help (sorry for the bad crop). Pilgrims scores a card, makes it cheaper, but makes you advance fewer crowns. But how much should that card be reduced by? The answer is on the next slide, but first, try to figure it out yourself. A cheat sheet:

Scoring: $8

Playing: $8

Card: $4

Crown: $4

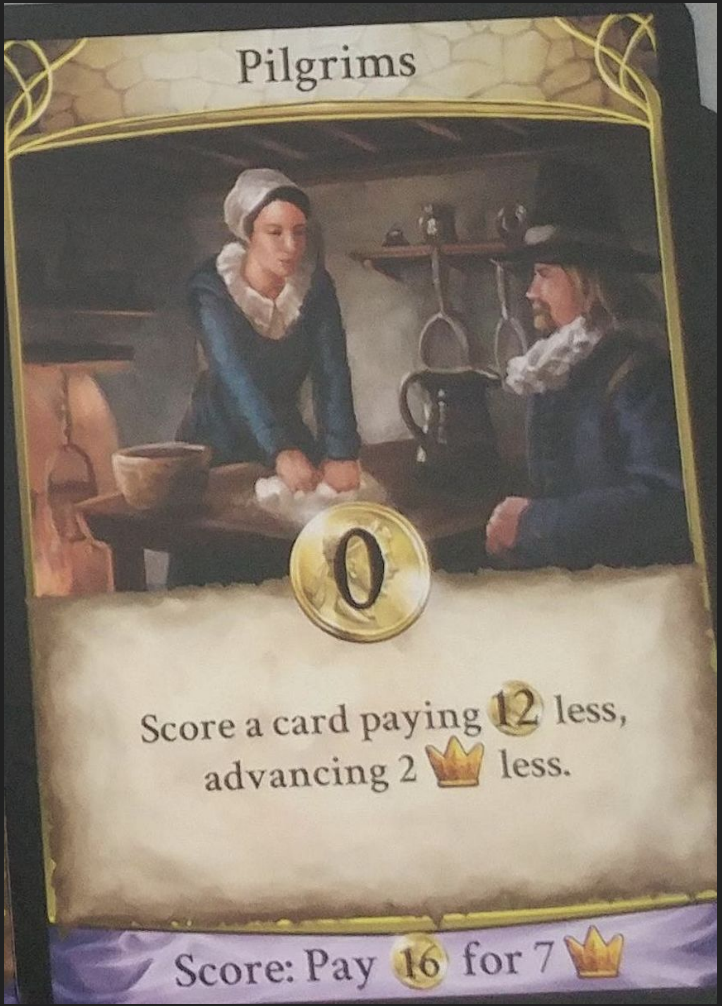


Pop Quiz

$8 [playing a card] + $4 [losing a card] = $0 [$ this gives you] + $8 [ability to score a card] + X [cost reduction] - $8 [advance 2 less crowns]

+$8 and -$8 cancels each other out, so the answer is $12.

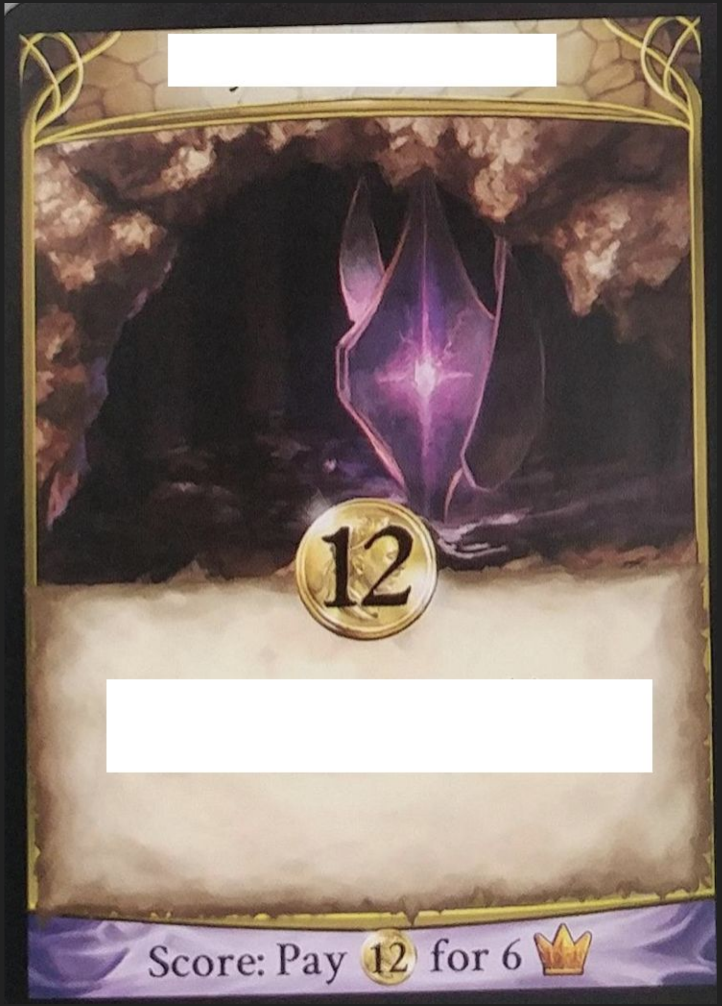
Now if Pilgrims instead advanced 3 fewer crowns, X would be 16 (since not many cards cost $16 to score, this isn't a great option). And if X needed to be $8, Pilgrims would have to advance 1 fewer crown instead of 2. And so on.



Game Length

Another thing math can be used for is figuring out how long the game will take. Imagine an even simpler version of Temporum, where all the cards are the same: they give +$12 when played, have no other abilities, and their scoring formulas are all $12 for 6 crowns.

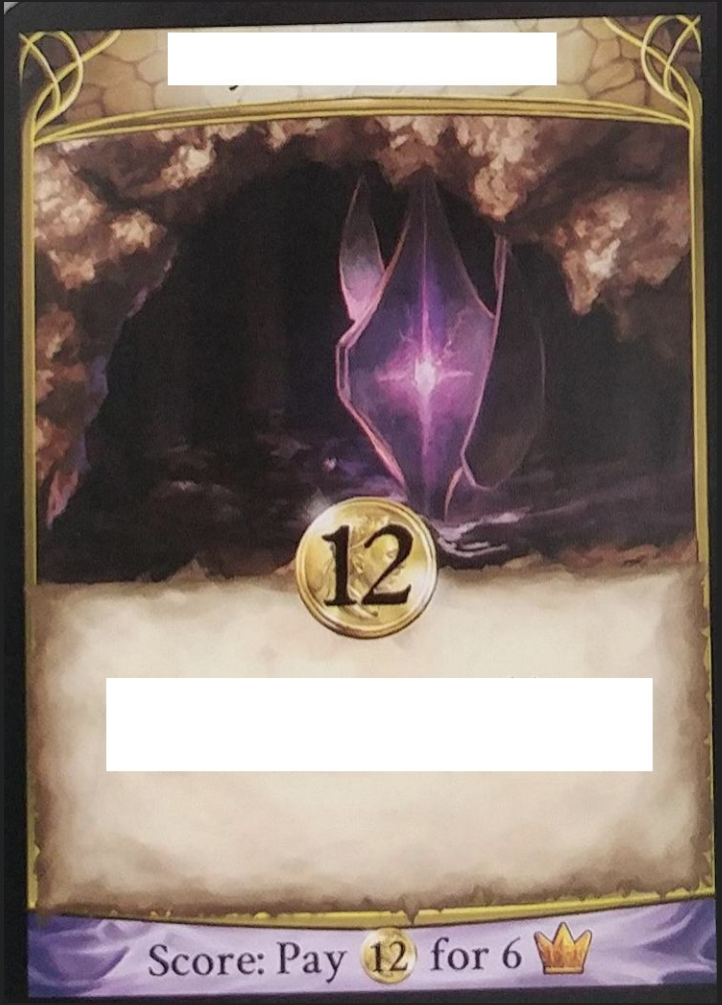
The gameplay loop will be to spend 3 turns doing the following: draw 2 cards, play 1 card for +$12, then spend that $12 to score the 2nd card for 6 crowns. Do this 5 times and you'll reach 30 crowns and win.



Game Length

You start the game with 2 cards for free, which is like getting a free turn of +2 cards. This means it'll take 3 turns×repeat 5 times-1 free turn in setup = 14 turns to win.

Another way to calculate this. To get to 30 crowns, you need 30×\$4=\$120, and since you start with 2 cards, that means you need \$8 less. Now since each turn is worth \$8, that means the game takes (\$120-8)÷8=14 turns.



Actual Temporum

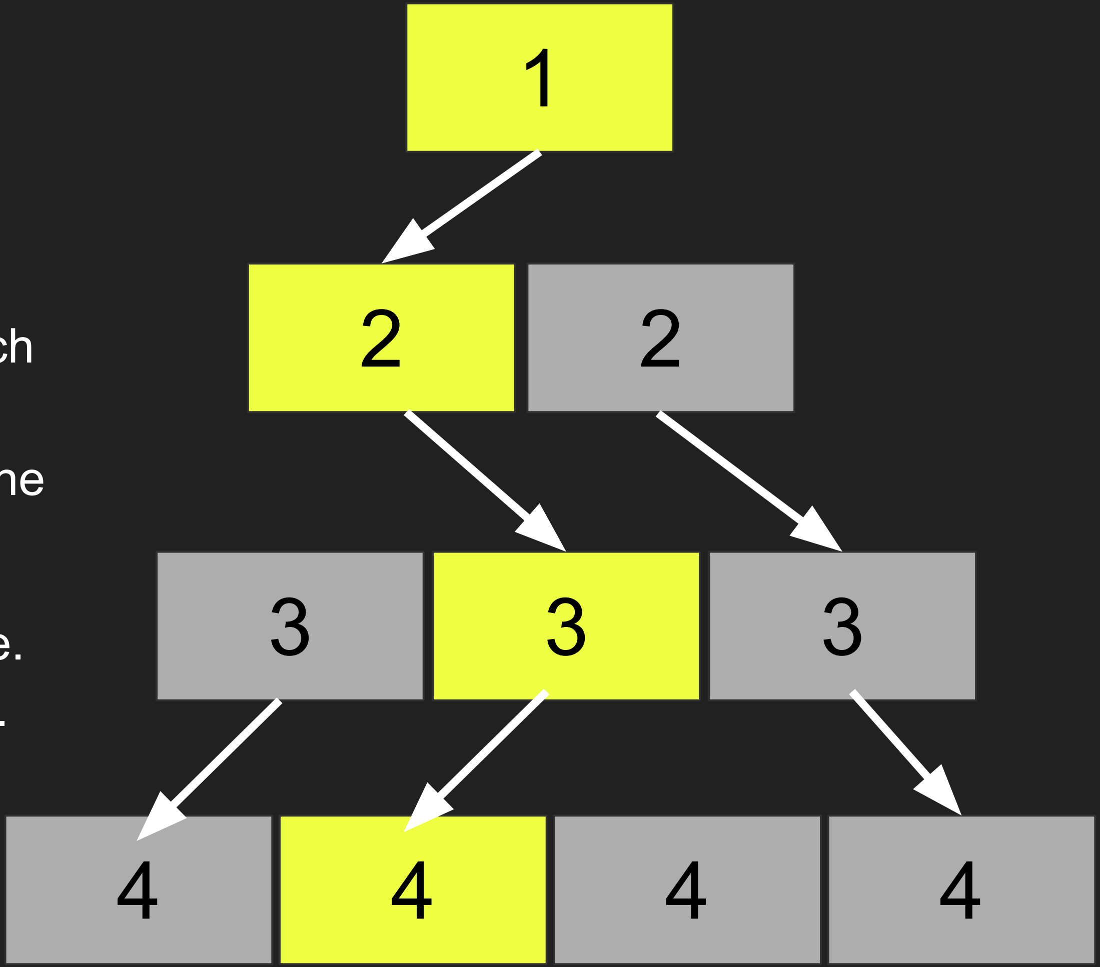
Now if this was the entire game, it wouldn't be very interesting. In the actual game, there are 4 time periods*. Each player begins with 10 crowns in Time 1. When you advance a crown, you move it to the next Time. You must advance each of your crowns, one by one, to Time 4 to win (that totals to 30 times)

* What's neat is that you can tell from the zone names that Time 1 is BC times, Time 2 is 1 AD - 1500 AD, Time 3 is 1500 AD - 2000 AD, and Time 4 is the future.

Actual Temporum

There are 10 zones picked each game. Only 4 of them are real at once (dictated by the arrows). Each turn, you can change the way the arrows face, and then you go to one of the 4 real zones.

Time 1 zones always let you score.
Time 2 zones always let you draw.
Time 3 zones always let you play.
Time 4 can do anything.



Ruling Times

If you're the player with the most amount of crowns in a Time*, you "rule" it. In this example, Alice rules Time 2 and 4, Bob rules Time 1, and no one rules Time 3.

	Alice	Bob
Time 1	8 Crowns	10 Crowns
Time 2	1 Crown	0 Crowns
Time 3	0 Crowns	0 Crowns
Time 4	1 Crown	0 Crowns

*In 4-5 player, it's the 2 players who have the most amount of crowns in a Time.

Ruling Times

Ruling Times is difficult. You only have 10 crowns to spread across the 4 Times (you never get more), and it also heavily depends on what the other players are doing.

Some cards care about how many Times you rule. Given how hard it is to rule a Time, these cards make the assumption that you'll only be ruling a maximum of one Time at any point in time. Making other players lose $2 is kind of like putting you ahead by $2, which means this card does a total of $12.

Ruling Times

But what if you managed to rule 2 Times, like Alice did 2 slides ago? Now Mayan Ritual Knife makes them lose $4, which would be $10+$4. $14, that's better than the standard $12.

Now of course, the game has to reward you for going out of your way to complete difficult challenges. But if a card consistently gives you too much, then it's just overpowered. Math helps here because it can immediately tell you if a card is overpowered or not.

Perpetual Cards

Temporum also has Perpetual cards, which are permanent abilities. How often you get to use their abilities varies depending on how early you get to play them.

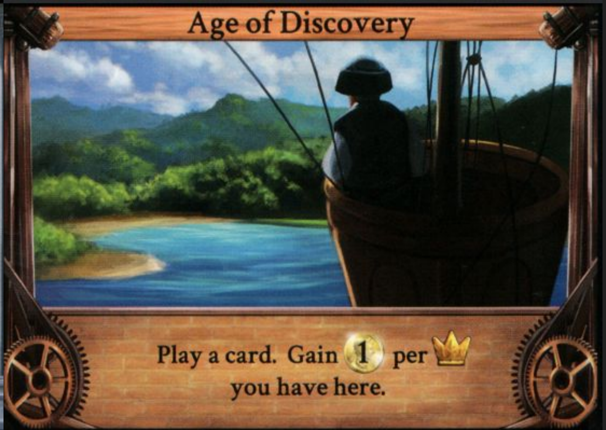
If you remember, on slide 11 I determined that you'll visit Time 2 four times during the game. Say you're lucky get to play Explorer turn 1, and then go to Time 2 four times in the game, you'll draw 8 cards and get $8 from Explorer's ability.

Perpetual Cards

What’s more likely though is you play Explorer and then only get +$6 total from the ability. Any later than that and you’re better off not playing Explorer at all. One nice thing about this game is that, if a card isn’t going to be good when played, you can find a different way to use it (probably by scoring it). Of course you can find ways to get more $ out of Explorer too (such as playing an Artist).

Balancing Zones

The zones in the game are also balanced around math. Each turn is spent visiting a zone, which means each zone has to do $8 or else it’s bad to visit it (you could’ve visited a different zone that would’ve done $8). As mentioned earlier, Time 1 always scores, Time 2 always draws 2 cards, and Time 3 always plays. That automatically fulfills the $8 baseline that a zone is required to do (any other bonuses they give is a cherry on top). But what about Time 4?



Balancing Zones

Utopia is a zone in Time 4. It draws 1 card ($4) and gives $4, that's $8. But it also protects you from losing $ or cards. So if you're here when another player plays Mayan Ritual Knife, you would've lost $2, but Utopia means you didn't lose $2, so visiting it was like getting an additional +$2.

Balancing Zones

Another example. A tricky thing here is that when you score 2 different cards, you're losing 2 cards. But when you score 1 card twice, you only lose 1 card. Scoring a card twice is like getting a free +1 card. The math for Age of Cats is then: -$10 + $8 (scoring) + $8 (scoring) + $4 (free card) = $10, which is better than the default $8 from visiting a Zone. But this does require you to have a lot of money.

Hourglass Zones

Here’s a mechanic from the expansion. Hourglass zones start with 1 hourglass per player in the game. When you visit it, remove an hourglass from it. Then if you removed the last hourglass, re-add all of them, and the zone will affects all players. Everyone can contribute to how fast it happens, and the zones also require you to meet a requirement in order to take advantage of it (for Celtic Paradise, have less than $8).

Hourglass Zones

If you have less than $8 and the other players don’t, that’s a free +$8 for you (in addition to the +$8 you got from the 2 cards). But if all players get +$8 from this, then the benefit basically cancels out. The math assumes everyone profits from this (players can and should plan for if/when the hourglass effect will happen), which is why they’re allowed to have giant effects like this.

Limits of Math - Joy

Now math seems like this great tool, but it’s not perfect. The summary of these next 5 slides is: math cannot replace playtesting (ok nothing will, but math is the topic of this presentation).

No amount of math will tell you (the game designer) if players are enjoying the game or not (or if it’s overwhelming/confusing). I made Temporum seem like a really well designed game, but the harsh reality is that it received mixed reviews (also chances are, you’ve never heard of this game before). I won’t get into specifics on why people didn’t like the game, but it’s because of the game’s mechanics, and you can’t fix the problem by just throwing more math at it.

Limits of Math - Rage

If all the cards are balanced, does that make the game better? Not necessarily; it is totally possible that you *don’t* want a card to be balanced, because it’s too annoying if it constantly gets played. You can make the card weaker to prevent people from ragequitting, but the point is, math cannot predict/identify these kinds of cards (and the only way to actually find them is to playtest).

I’ll share a quote by Donald X: “Me being right on the math doesn’t make me right on player experience. People who hate something are right, they do actually hate it, why am I sucking the joy out of the game with this completely fair and reasonable thing. No amount of the math saying it’s fine makes the difference.”

Limits of Math - Applicability

Math may have worked for Temporum, but it won’t work for all games. You know Dominion, Donald X.’s most popular game? There’s some math in that, but not so much for balancing cards.

One problem is, the game’s basic resources (+cards, +actions, +buys, +coins) don’t carry over between turns. But also, it’s very hard to assign numbers to them. +2 Actions is better than +1 Action, but +1 Action is way better than +0. And +1 Buy is good, but sometimes you can’t even use it. And +1 Card is really weak, unless it also comes with +1 Action (then it’s great).

The point is, you can’t use math to empirically determine what a Dominion card should cost. You can compare a new card with already existing cards, and try to guess the best cost, and that’s all you can do.

Limits of Math - Assumptions

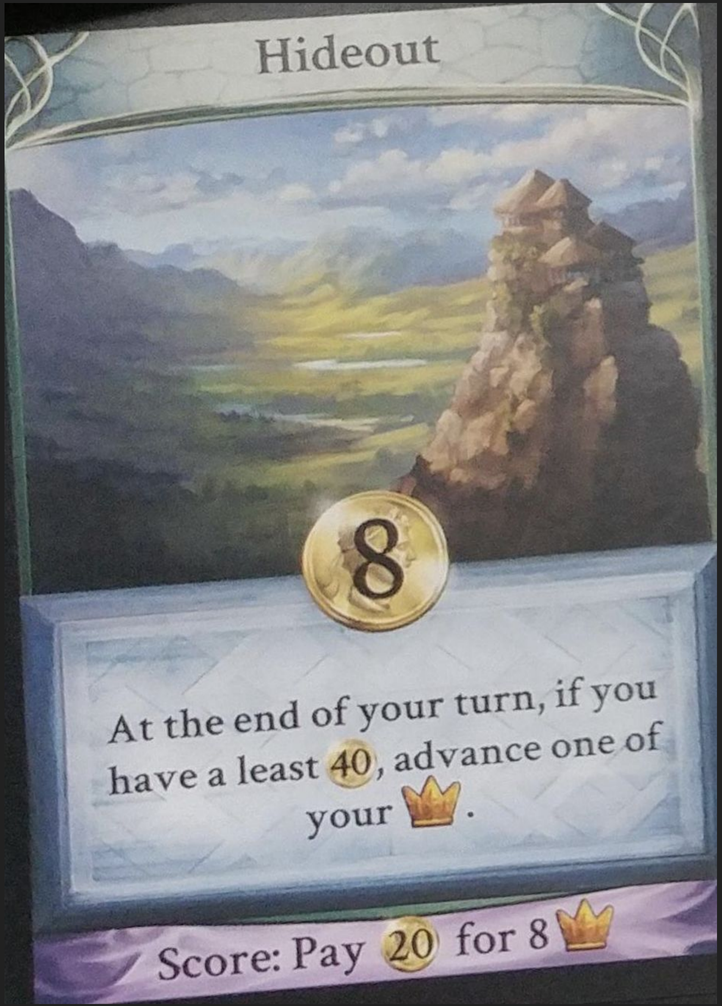
Finally, math will require you to make assumptions on some stuff. In Temporum, the cards assume the most common situation is that you’re only ruling 1 time. But what if that assumption is wrong, and it turns out you can rule 2 times pretty consistently?

And the game assumes that 1 card = $4 = 1 crown, but that doesn’t mean you can treat them as 100% identical. For instance, large amounts of +$ and +Card are fine. But you have to be more cautious with large amounts of +Crown, because +Crowns directly translates into winning the game.

Limits of Math - Assumptions

Also, Perpetual cards like Explorer assume you'll use them 3x, but what if it turns out they become problematic if you use the 4x, and that happens too often?

And then, what about Perpetual cards that will require more work to activate? For example, Hideout wants you to have a lot of money, except how do you calculate what that number should be? It's harder to make a guess there.



Designing using Math - Baseline

If you want to make your own game that uses math, where do you start? I’m not an expert with this tool or anything, but I can share some insights (still using Temporum as an example).

You want to have a baseline that everything else can be compared to. Again back to slide 10, I came up with a card that was +$12, no abilities, score for $12 for 6 crowns. That was the baseline for Temporum. Sure you probably aren’t putting it in the game (the Temporum baseline doesn’t exist because it’d be very boring), but that doesn’t mean you shouldn’t come up with one anyway.

Designing using Math - Interchangeability

In Temporum, cards, coins and crowns can all be interchanged for each other. This lets you make simple variations of different cards. For example, some cards in the game are basically \$8 + \$4. Now a card that was literally \$8 + \$4 would look weird, but you can do other stuff that's mathematically equivalent, such as: \$8 + 1 card, \$8 + make them discard, \$8 + 1 crown, and \$8 + make them retreat 1 crown.

And you can continue with \$4 + 2 cards, or \$4 + play, or \$4 + score, or \$4 + 1 card + 1 crown, or \$0 + 3 cards, \$0 + 3 crowns, or \$0 - 1 card + score + play, and so on. Not all those combinations got printed, but they'd automatically be balanced and simple cards.

Designing using Math - Granularity

Granularity is, how large is the difference between 1 of something and 2 of something? The difference in +$1 and +$2 is small. The difference in +1 Card and +2 Cards is much larger (1 card = $4). $ is more granular than cards.

Since $ is granular, you can make cards like $8 + they lose $4, or $10 + they lose $2. Notice that you probably aren't doing all possible combinations. $9 + they lose $3 feels redundant and random if you're already doing those other 2. And you can't make the attack too strong ("$0 + they lose $12") or else there's a high chance of ragequitting.

But more importantly, notice that you can't do any of that with cards or crowns, they lack that granularity.

Designing using Math - Granularity

Granularity also makes it easier to balance cards. You could have a card that looks balanced on paper, but in practice it’s actually quite strong and you want to make it weaker. In Temporum, you can make cards weaker by reducing the amount of $ they gives.

For example, Golden Goose looks like it should give $17, but it gives $16 to be slightly weaker. Sure it helps the opponents, but you could arrange it so they can’t use the $5 fast enough. (After all, any $ left at the end of the game is wasted!)

Designing using Math - Granularity

But what if $ wasn't granular, and instead $1 = 1 card = 1 crown? In this alternate reality (this is a pun), reducing a card by $1 would be a huge nerf and it basically wouldn't be an option (unless you change the ability, but that may not end up working either). Granularity means you can make small tweaks to numbers and it will only be a small nudge (which is what you want).

Of course there's a limit to how granular you can make something. For a board game, you don't want to force players to manage decimal money ($0.5), and then trying to draw 0.5 or 0.25 cards is impossible. You could multiple everything by 2x to avoid decimal money and cards, but you can only go so far there; large numbers are also hard for players to manage, and having players draw more cards means that they have to do more reading.

Designing using Math - Differentiability

What I mean by differentiability is, are amounts of the same resource always identical, or can they be different from each other? The cards in Temporum are inherently different from each other because they have different +$ amounts, instructions, and scoring formulas. The crowns can also be different from each other because they can be positioned in different Times.

Money meanwhile doesn’t have this, all money is the same. Expressed more cynically, money is just a number going up and down. There’s nothing wrong with that, but just like how you want some very granular resources, you also want some resources with differentiability. The design space with money is lpw; the design space with cards is larger and more interesting.

Designing using Math - Differentiability

Another reason why this matters. When you have multiple resources, an obvious thing you can do is to trade 1 resource for another. After all, scoring a card is trading a turn, a card, and money for crowns. But what about trading a resource for itself?

You can make “draw 2 cards, discard 2 cards” because cards are different from each other. You can discard cards that aren’t useful right now, and maybe you’ll draw better ones. “Gain $4, lose $4” meanwhile would be pointless, because all money is the same.

Designing using Math - Ideas

Finally, you want to create different jumping off points for ideas. You want to find ways to make cards you wouldn't have made before.

The amount of $ a card makes in Temporum is entirely dependent on its abilities. Most cards could be made by thinking, what's an ability, and then figure out how much $ it should make.

(A hint: make some cards that take advantage of what's special about your game. You could do Artist in tons of card games. Step on a Butterfly is something that can only be done in Temporum.)

Designing using Math - Ideas

But you can do it the opposite way as well. What if you determine a specific number of $ a card should give first, and then figure out the ability from there?

For example, if you have several cards that make $8, come up with some cards that make $4 (you want cards to make different amounts of $ so they don’t all feel the same). If you were forced to make a card makes $2, what would it do? What if it made $17?

Of course there are many other ways to come up with ideas, but you still want to create as many of those ways as possible, and this is one.