WORKING PAPER · CATAN SIMULATION PROJECT

How Catan Is Won

Opening placement, the middle-game race, and the endgame, measured across 100,000 simulated games and a search bot

Data: baseline_4p (100k games), econ_base20k (20k games), placement labs, and 600 MCTS-vs-tuned games · November 2026

Summary

Rule-exact bots played 100,000 four-player games of Catan. Each game was tracked from the first settlement to the winning point. The opening decides more than anything that follows. The player with the best starting spots wins 33% of games; the player with the worst wins 15%. A starting pip of ore or wheat is worth about 1.5 pips of wood, and covering all five resources adds about 5 points of win probability on top of the pips. The snake draft gives every seat about the same total pips, but not the same kind. The first pick takes the ore; the last seat gets two picks in a row and the most variety. In the middle game the start becomes a production lead, and by round 12 the player in front wins almost half the time. In the endgame the first player to 8 points wins 63% of games, usually about two rounds later. Cities, a hidden victory-point card, and one of the two awards make up most of the gap. A search bot (MCTS) that beats the best tuned bot draws most of its edge from a handful of decisions per game: where to build roads, when to play a knight, and which trades to refuse.

Key findings

1. **Pips first, then ore and wheat, then variety.** Win rate rises from 11% to 38% across the range of starting pips. Holding pips fixed, ore and wheat pips are worth the most, and a start that touches all five resources wins twice as often as one that touches three.
2. **The draft order changes what you get, not how much.** All four seats end setup with about 19.6 pips. Seat 1 gets the best single spot and the ore; seat 4 gets the widest mix. Seat 1 still wins 25.9% and seat 4 24.0%.
3. **Production now beats starting pips later.** At round 10, a player's current production, development cards, and distance from the leader predict the winner. Once those are known, starting pips add nothing. The start matters through the engine it builds.
4. **The lead hardens around round 12.** The leader's chance of winning climbs from 38% at round 3 to 55% at round 18. The last-place player's falls from 22% to 10%. Never building a city is fatal (5% win rate).
5. **The endgame is a sprint from 8 points.** The first to 8 public points wins 63% of games. Winners take about 2.4 cities, and three in four finish with a hidden victory-point card.
6. **The search bot plays roads, knights, and refusals.** Its edge over the tuned bot comes from better road placement, knights played instead of trades, and declining trades that help the partner more. Most of that edge lands in the middle game.

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1 The question

What wins a game of Catan, and when is it decided?

Catan mixes luck with judgment. The dice decide what each hex produces. The players decide where to build, what to trade, and when to spend. The real question is how much each choice matters, and at which point in the game. Concretely:

- How much of the result is set by the two opening settlements, and what makes a good one: total pips, particular resources, variety, ports?
- How does the snake draft order change the best opening?
- In the middle game, what puts one player in front, and what makes the others fall behind?
- How does the endgame play out, and what does a strong search-based player do differently from a good rule-based one?

To answer these, a complete rules engine ran with bots that negotiate trades. Every placement, roll, trade, build, and steal was logged, then related to winning. Effects are reported in **points of win probability**. In a four-player game an average player wins 25%, so "+5 points" means 30%.

2 The game in five minutes

> FOR NEWCOMERS
> Players build settlements, roads, and cities on an island of 19 hexes. The first to 10 victory points wins. Everything built is paid for with resource cards, and those cards come from dice rolls.

The board. Each hex produces one of five resources: **wood** (forest), **brick** (hills), **sheep** (pasture), **wheat** (fields), and **ore** (mountains). There are four hexes each of wood, sheep, and wheat, three each of brick and ore, and one desert. Every producing hex carries a number from 2 to 12.

Dice and pips. Each turn starts with a roll of two dice. Every hex showing the rolled number pays one card to each settlement on its corners, and two to each city. Some numbers come up more often than others. The number token shows this with dots, called **pips**: the number of ways two dice can make that total.

Table 1. Pips per number token

Number	2	3	4	5	6	8	9	10	11	12
Pips (ways out of 36)	1	2	3	4	5	5	4	3	2	1
Chance per roll	3%	6%	8%	11%	14%	14%	11%	8%	6%	3%

A spot's pips are the sum over the up to three hexes it touches. An average spot has about 10, and a strong one 12–13. A 7 is rolled 6 times in 36 but has no hex. It moves the robber instead (below).

What things cost. Every build has a fixed recipe:

- **Road**: wood + brick. Roads connect buildings, and new settlements must be placed at the end of one.
- **Settlement** (1 point): wood + brick + sheep + wheat. It must be at least two corners away from any other building (the *distance rule*).
- **City** (2 points): 2 wheat + 3 ore, upgrading a settlement. It doubles that corner's production.
- **Development card**: sheep + wheat + ore. Most are *knights*, which move the robber. Others are victory-point cards (hidden until the end), Road Building, Year of Plenty, and Monopoly.

Bonus points. The longest continuous road of at least 5 segments earns *Longest Road* (2 points). The most knights played, at least 3, earns *Largest Army* (2 points).

The opening draft. Before play starts, each player places two settlements, each with a road, in a **snake order**: 1, 2, 3, 4, then 4, 3, 2, 1. Seat 1 picks first and last; seat 4 picks twice in a row in the middle. The second settlement also pays one card of each hex it touches, so players begin with a small hand.

Trading. On their turn a player can trade cards with others on any terms both accept. They can also trade with the bank at 4 cards for 1, or at 3:1 or 2:1 if they have a settlement on a *port*.

The robber. When a 7 is rolled, anyone holding more than 7 cards discards half. The roller then moves the robber onto a hex, which stops it producing, and steals a card from a player there. Knights move the robber too.

How we measured. The games are played by bots built on an exact implementation of the base rules. Six bot styles (balanced, ore-and-wheat cities, expansion, development cards, port trading, and hoarding), each with randomly varied weights, give 100,000 games of varied but competent play. For the search bot in Section 5, a Monte Carlo tree search player is also pitted against the strongest tuned rule-based bot over 600 paired games.

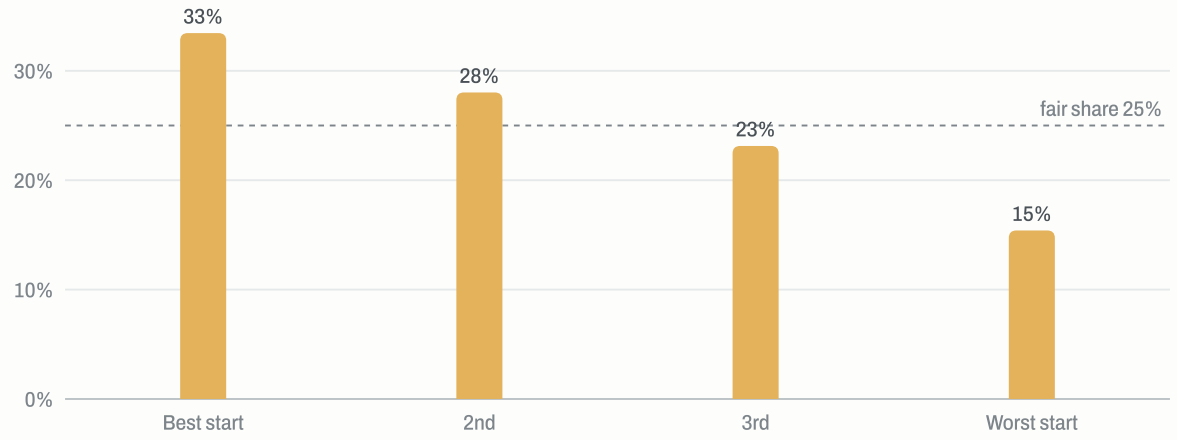
3 The opening placement

> IN SHORT
>
> Take pips. Among spots with similar pips, take ore and wheat, then fill in the resources you lack so the pair covers all five. The 6 and 8 are only worth their pips. A 2:1 port is worth a lot when you will produce that resource. Draft position changes which of these you can get.

3.1 Pips decide the most

The two opening settlements fix about half a player's production for the whole game, and they decide more than any later choice. Rank the four players in each game by the total pips of their two starting spots (Figure 1). The best start wins 33.4% of games and the worst 15.4%, more than double. The gap between them averages five pips.

Figure 1. Win rate by the quality of the start, ranked within each game



The best start in the game wins twice as often as the worst. baseline_4p, 100,000 games. Players are ranked by the total pips of their two setup settlements (ties broken by seat). Hover for the average pips.

Measured another way, each extra starting pip adds about 3 points of win probability. A player opening with 25 or more pips wins 31–47% of games depending on the mix, against 6–10% for 15 or fewer.

3.2 Which resources: ore and wheat first

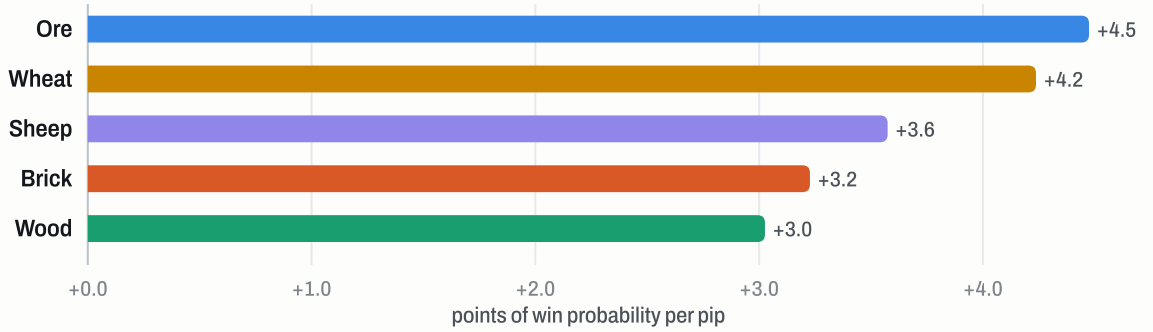
Pips are not all equal. A logistic regression of winning on starting pips by resource, holding everything else fixed, gives the value of one more pip of each (Figure 2):

- **ore** +4.5 points per pip
- **wheat** +4.2
- **sheep** +3.6
- **brick** +3.2
- **wood** +3.0

One ore pip is worth about one and a half wood pips. The reason sits in the recipes. Cities and development cards, which produce most of a winner's points, need ore and wheat. The board has only three ore hexes, and almost all ore gets built into something

(93% of it, against 43% of wood). The player market prices ore and wheat highest for the same reason, at about 1.15 average cards each against 0.85 for wood. Ore is the resource you cannot easily buy, so it pays to own it.

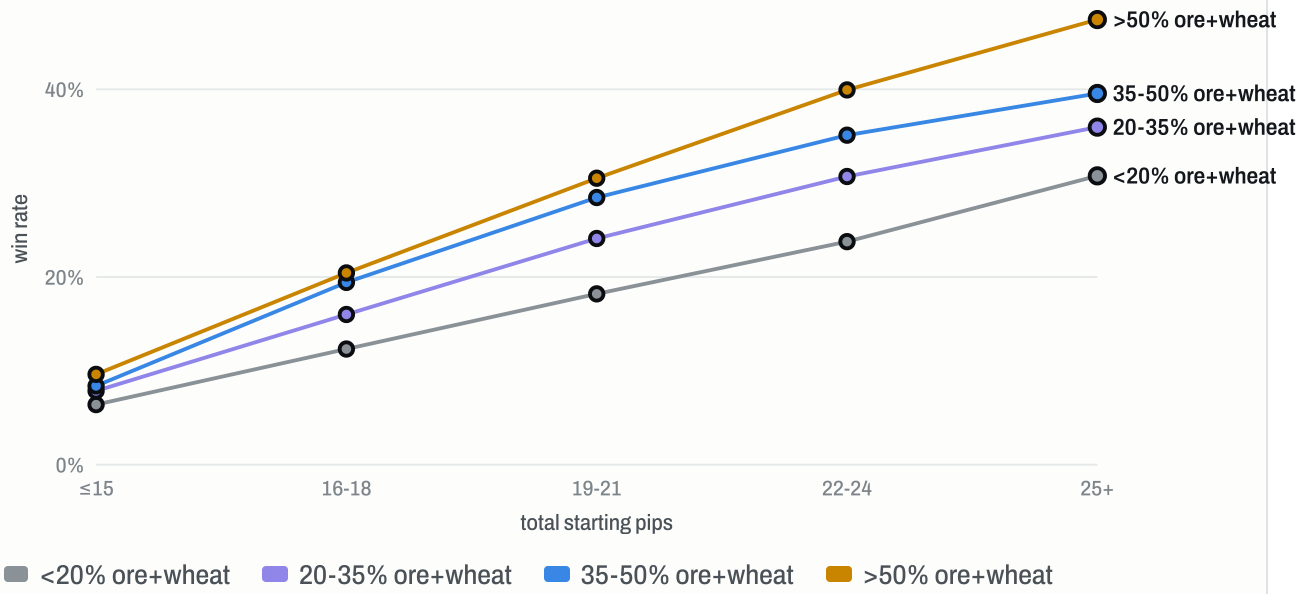
Figure 2. What one more starting pip of each resource is worth



Ore and wheat pips are worth the most. Average marginal effect on win probability from a logistic regression on 400,000 player-games. It also controls for diversity, 6/8 hexes, ports, and seat (Figure 4).

Figure 3 shows the same pattern in the raw data. Within every band of total pips, the share of the start that is ore and wheat lifts the win rate. At 19–21 pips, a start with under 20% ore and wheat wins 18%, and one with over half wins 31%. At 22–24 pips the range is 24% to 40%.

Figure 3. Win rate by starting pips and the share of those pips that are ore or wheat



At every pip level, more ore and wheat wins more. baseline_4p. Each line is a band of ore + wheat share of the starting pips. Hover for the number of player-games in each cell.

3.3 Variety: cover all five

The next rule is to cover the resources you lack. Players whose two settlements touch all five resources win 32.6% of games, those touching four win 25.4%, and those touching three win 18.9% (Table 2). Some of this is pips, since spots touching three different hexes have more of them. But the regression holds pips fixed and still credits each extra resource with about +5.3 points (Figure 4).

Missing a resource means buying it, usually at 4:1 from the bank or at a premium from other players. One combination matters most. A start that can make both a road (wood + brick) and a city (ore + wheat) wins 30.2%. Ore and wheat without the wood–brick pair wins 27.8%. Wood and brick without ore and wheat wins 18.9%. Neither pair wins 13.3%. About a quarter of players (24%) open with no ore at all. They win 18.0%, against 27.2% for those with some.

Table 2. Win rate by variety and by resource pairs in the start

Resources touched	Share of players	Avg pips	Win rate
2	2%	16.5	11.1%
3	23%	18.6	18.9%
4	54%	19.9	25.4%
5	**21%**	**20.5**	**32.6%**

Resource pairs	Share of players	Avg pips	Win rate
Both pairs	30%	20.2	30.2%
Ore + wheat, no wood/brick pair	34%	19.4	27.8%
Wood + brick, no ore/wheat pair	29%	19.7	18.9%
Neither pair	7%	18.0	13.3%

baseline_4p. "Diversity" is the number of different resources touched by the two setup settlements. The pairs are the city pair (ore + wheat) and the road pair (wood + brick).

3.4 The 6 and 8, and ports

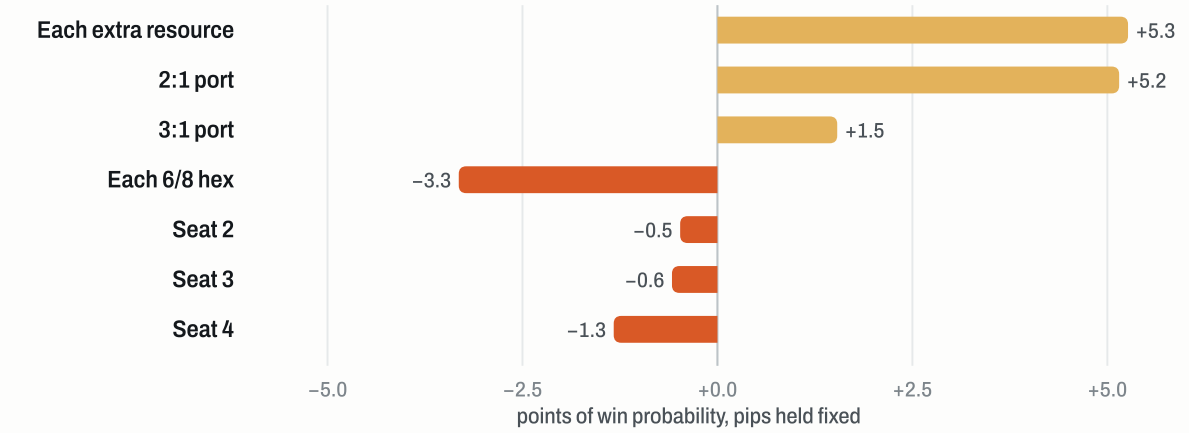
New players are often told to grab the 6s and 8s. In this data the red numbers are worth exactly their pips and no more. Players with zero, one, or two 6/8 hexes win 24.6%, 25.0%, and 25.0%, even though those with two have two more pips on average. With pips held fixed, each 6/8 hex is worth about -3.3 points.

Why? Concentration and the robber. Pips on one big number pay out in bursts, which pushes hands over 7 and invites discards. Those hexes are also the ones the robber targets first. A 5 + 9 + 10 spot produces as much as a 6 + 8 + 2 spot, and more steadily.

Ports are worth a lot only when they match production. A 2:1 port in the start adds about $+5.2$ points with production held fixed, and a 3:1 port adds $+1.5$. In the raw data, though, port openers win *less* often, because port spots on the coast usually have

few pips. A port is a good second settlement when it trades the resource your first settlement produces in bulk.

Figure 4. Other features of the start, with pips held fixed



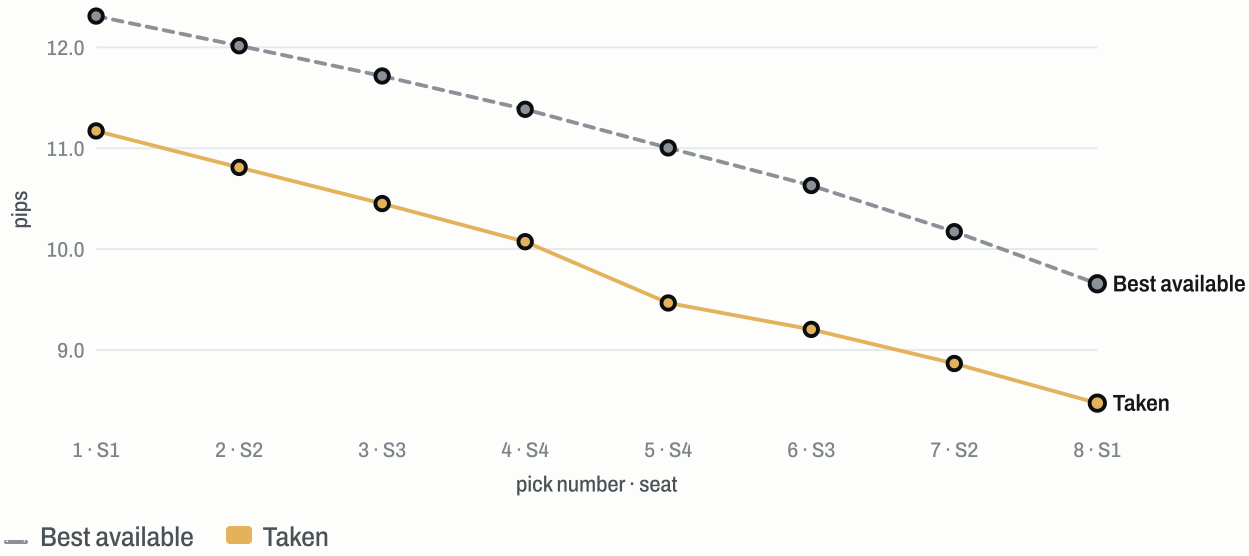
The same regression as Figure 2. Diversity is per extra resource covered, and 6/8 is per 6- or 8-hex touched. Seat effects are relative to seat 1.

3.5 How the draft order changes the best opening

The snake order means the spots get worse as picks go by, but not evenly (Figure 5). The first pick of the game takes a spot worth 11.2 pips on average, and the eighth pick 8.5. The best spot still available falls from 12.3 to 9.7.

Bots take the single highest-pip spot only about 44% of the time. They usually give up a pip or so for the right resources or for variety, which Section 3.3 shows is worth it.

Figure 5. Pips of each setup pick, in snake order

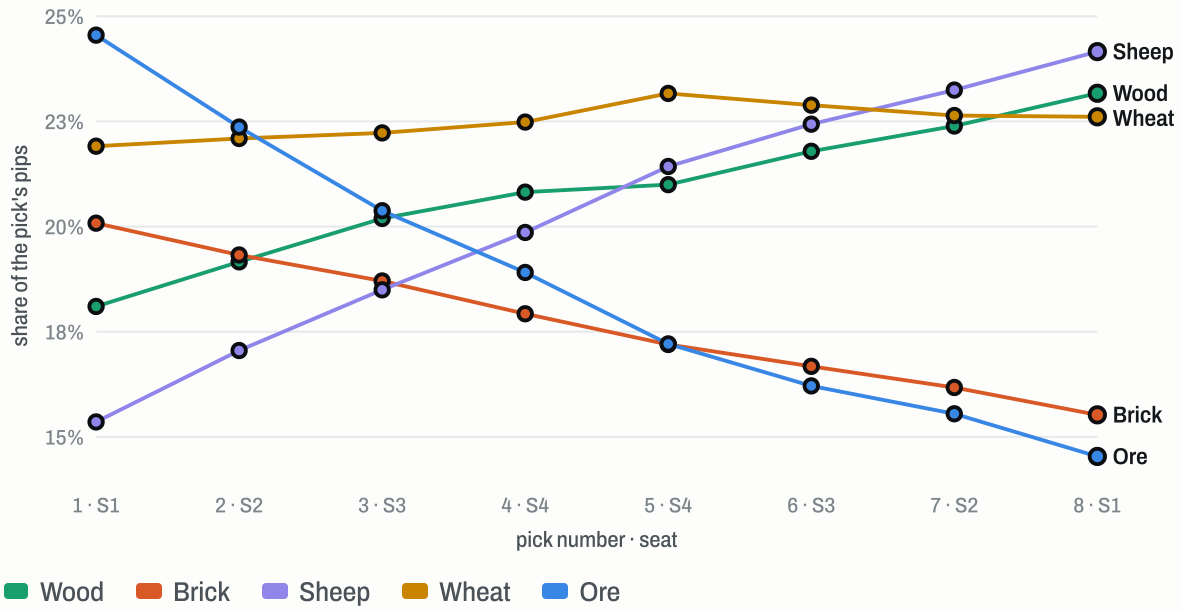


Each pick is worse than the one before, and the best spot left falls with it. baseline_4p, 100,000 games. "Best available" is the highest-pip spot still legal under the distance rule when the pick is made.

The snake order evens out the totals. Seat 1 gets the best first spot and the worst second one; seat 4 gets the reverse. All four seats end setup with 19.5–19.7 pips (Table 3). What differs is the *kind* of pips each seat gets (Figure 6).

- **Early picks take the ore.** Ore is 24.6% of the pips taken by pick 1 and only 14.5% of those taken by pick 8. Brick follows the same pattern. Both are scarce (three hexes each), so they run out first.
- **Late picks are left with wood and sheep.** Their share rises from 18% and 15% at pick 1 to 23% and 24% at pick 8.
- **Seat 4 gets the widest mix.** Picking twice in a row lets seat 4 choose a matched pair at once. It ends with the highest diversity (3.97 resources, against 3.89 for seat 1).

Figure 6. Resource mix of each pick, in snake order



Ore and brick are taken early; wood and sheep are what is left. Share of each pick's pips by resource.

Table 3. The opening by seat

Seat	1st settlement	2nd settlement	Total pips	Resources	Win rate
Seat 1	11.2	8.5	19.6	3.89	25.9%
Seat 2	10.8	8.9	19.7	3.91	25.2%
Seat 3	10.5	9.2	19.7	3.93	24.9%
Seat 4	10.1	9.5	19.5	3.97	24.0%

Average pips of each seat's first and second setup settlement, the number of resources touched, and the win rate (fair share 25%).

So the best plan depends on the seat.

- **Seat 1** should take the best ore-and-wheat spot available. Its second pick comes last, when only wood and sheep remain, so the first spot has to carry the city plan.

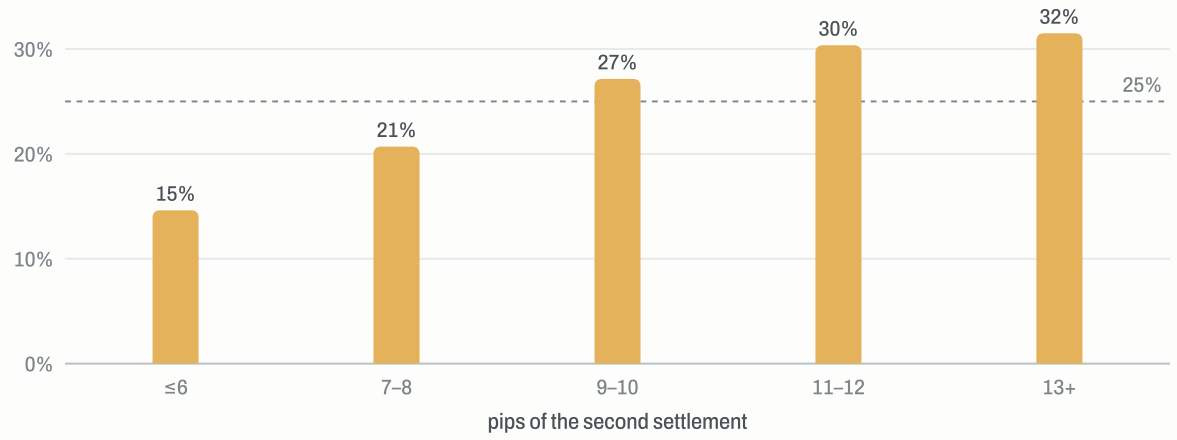
- **Seats 2 and 3** should balance pips against what will be left. Ore will be mostly gone by their second pick.
- **Seat 4** should pick its two spots as a pair: one for pips, one to fill the gaps. If the ore is gone, a strong wood–brick–sheep pair for early expansion is the fallback.

The seat effect on winning is small. Seat 1 wins 25.9% and seat 4 24.0%, and the regression puts seat 4 at −1.3 points against seat 1 with the start held fixed. Part of seat 1's edge is simply moving first in the main game.

3.6 The second settlement

The second settlement matters nearly as much as the first. Players whose second spot has 6 pips or fewer win 14.6% of games, and those with 10–12 win 30.4% (Figure 7). For seat 1 the second pick is the last of the draft, which is why its first pick has to be strong.

Figure 7. Win rate by the pips of the second setup settlement



baseline_4p, all seats.

3.7 How the start shapes the rest of the game

The opening sets the production a player will have, and with it the plan they can follow. Two experiments test whether that plan should follow the board.

Choosing a plan before placing. In the strategy lab, each bot chose a style before setup. The balanced placement (pips, ore and wheat, variety) won the most in every seat, from 36.6% in seat 1 to 34.0% in seat 4 (Table 4). Committing early to a narrow plan, such as port trading or pure expansion, cost 14–17 points in every seat.

Changing plan after placing. In the replan lab, every bot placed the balanced way and then switched style for the rest of the game. Playing in the port-trader style after a balanced placement was the only switch that helped: +1.3 points (±0.8). It was also the best follow-up for weak, average, and strong starts alike. Every other switch cost 4.6–8.4 points.

Place for balance first. Afterwards, use the bank and ports to turn the surplus your spots produce into what they lack, rather than chasing one resource.

Table 4. Placement style by seat (strategy lab) and follow-up style after a balanced placement (replan lab)

Seat	balanced	dev_army	ore_wheat_city	hoarder	expansion	port_trader
1st	36.6%	32.6%	30.1%	28.0%	21.7%	21.7%
2nd	36.4%	31.5%	28.8%	27.2%	22.2%	19.7%
3rd	35.0%	31.0%	27.5%	25.9%	21.6%	19.4%
4th	34.0%	28.6%	27.0%	24.7%	20.2%	19.6%

Start strength	then port_trader	then expansion	then dev_army	then ore_wheat_city	then h
weak	+1.5	−3.3	−7.6	−6.8	
average	+0.3	−5.1	−6.9	−8.3	
strong	+2.2	−5.5	−6.5	−7.9	

Strategy lab: win rate of each style when it both places and plays, by seat. Replan lab: change in win probability against staying balanced, by strength of the start, 2,000 positions each.

4 Early and middle game: taking the lead

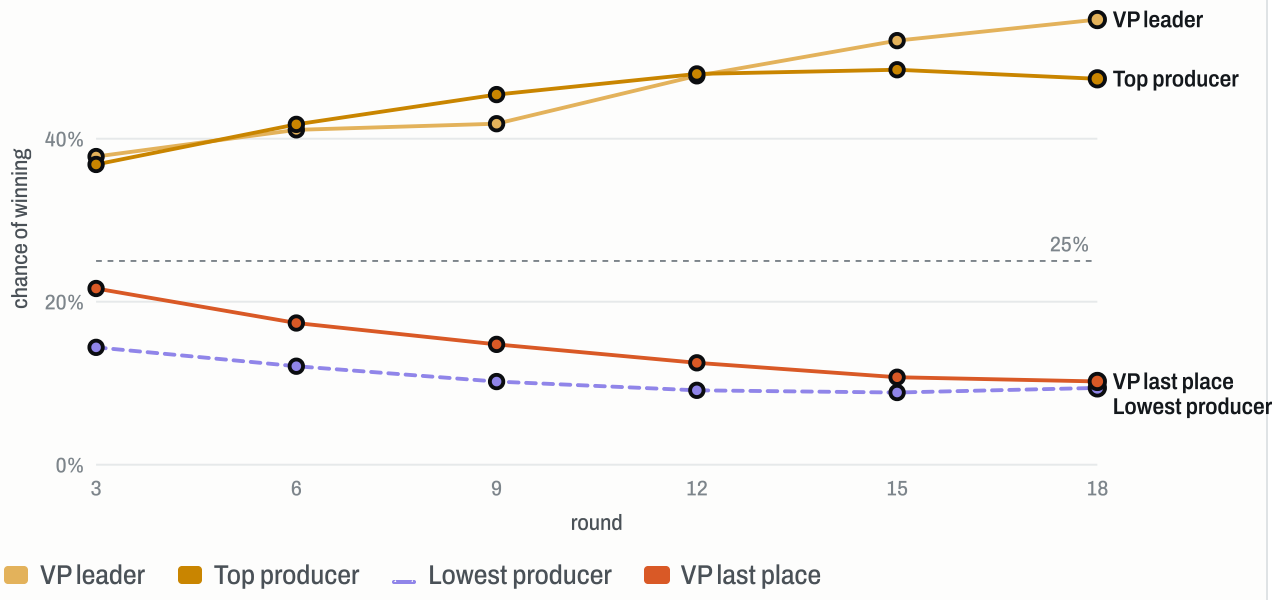
> **IN SHORT**
>
> The opening turns into a production lead, and the production lead turns into a points lead. From round 10, being level with the leader, producing more, and holding development cards matter most. Players fall behind from thin production, a late or missing first city, and cards lost to the robber and discards.

4.1 The lead hardens over time

Early leads are fragile. The player with the most points at round 3 wins only 37.8% of games. By round 12 the leader wins 47.7%, and by round 18 54.6% (Figure 8). Last place goes the other way: 21.6% at round 3, close to an even chance, and 10.2% by round 18.

Production predicts the winner sooner than points do. The player with the highest production at round 3 wins 36.8%, and by round 12 that reaches 48%. The lowest producer falls to 9%.

Figure 8. Chance of winning by standing at each round

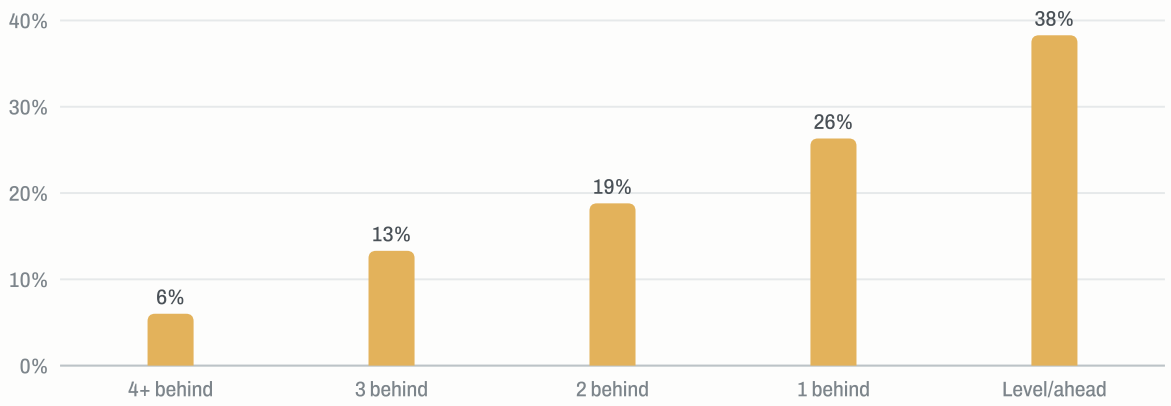


Leads harden from round 9 to 15. econ_base20k, 20,000 games. Ties for first are counted as leading. Later rounds include only games still in progress. Half of games end by round 19.

The lead still changes hands. Only 20% of games keep the same sole leader once one emerges. In 27% the lead changes once, in 29% twice, and in 24% three times or more.

Distance to the leader at round 10 is a good guide to a player's chances (Figure 9). Level or ahead, they win 38%. One point behind, 26%. Two behind, 19%. Four or more behind, 6%.

Figure 9. Win rate by VP behind the leader at round 10



Public VP. The −4 column includes players four or more points behind.

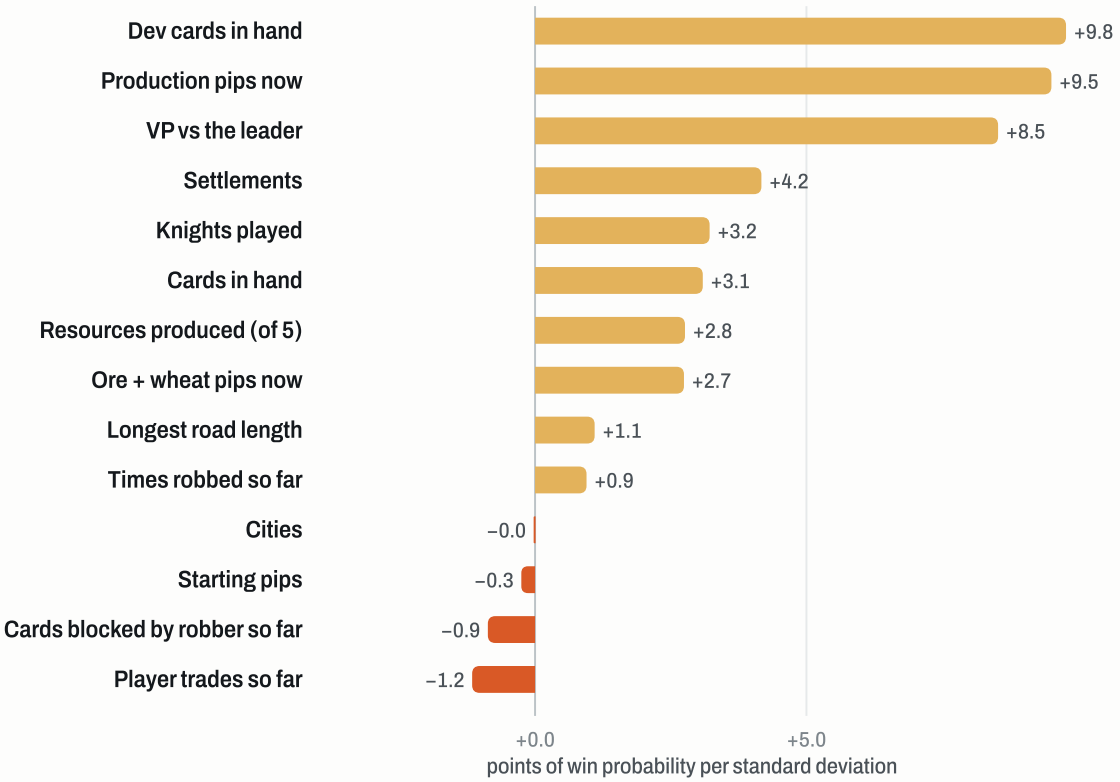
4.2 What decides the middle game

Take a snapshot of every player at round 10 and ask which features predict winning, holding the others fixed (Figure 10). The strongest are:

- **Development cards in hand** (+9.8 points per standard deviation). These include hidden victory points, and knights that are ready to play.
- **Production pips now** (+9.5). This means after any new settlements and cities, not at the start.
- **Points relative to the leader** (+8.5).
- **Settlements** (+4.2), **knights played** (+3.2), and **cards in hand** (+3.1).
- **Ore** + **wheat production** (+2.7) and **diversity** (+2.8). These are the same opening preferences, still paying off at round 10.

Starting pips add nothing once current production is known (−0.3, not significant). That is the link between the opening and the middle game. The start matters because it seeds the production engine. By round 10, what counts is how far that engine has grown.

Figure 10. Round-10 position and the chance of winning



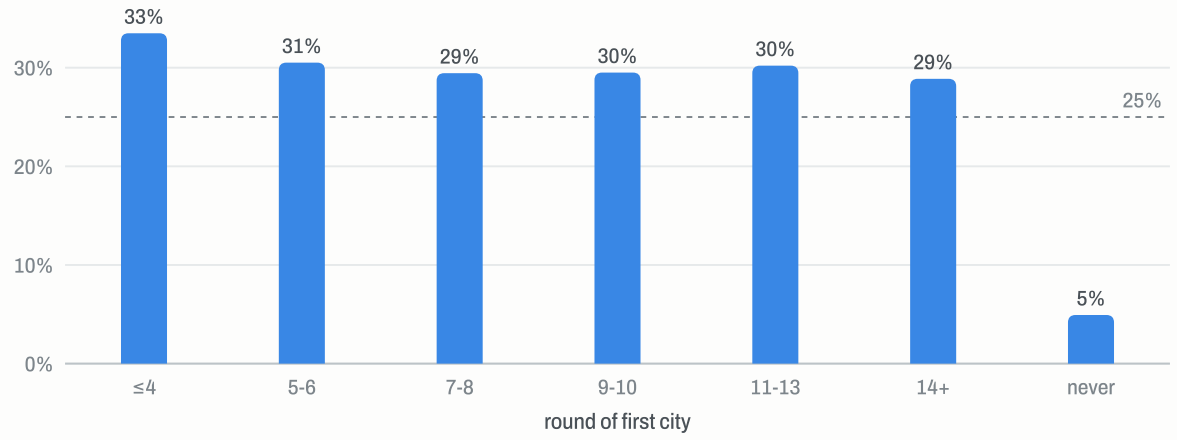
Production, development cards, and closeness to the leader matter most. Change in win probability per standard deviation of each feature, from a logistic regression on 80,000 player snapshots at round 10. Cities show no effect because their points are already in "VP vs leader". "Times robbed" is positive because the robber targets players who are doing well.

4.3 The first city

A city doubles a spot's output, and it is the single most telling milestone. Players who build their first city by round 4 win 33.5%. Those who build it in rounds 5–13 win 29–31%, and from round 14 on 28.9%. Players who never build one win 4.9% (Figure 11).

Timing matters less than doing it at all. More than half of players (55%) have no city at round 10, and they win 19.9%.

Figure 11. Win rate by the round of the first city



econ_base20k, all players.

4.4 Why players fall behind

Falling behind is rarely one bad roll. It is usually one of four slow leaks.

- **Thin or one-sided production.** A start missing ore (24% of players) or the city pair cannot build cities without buying, and buying costs 2–4 cards for one.
- **Lost output.** For every 100 cards a player's buildings could produce, about 34 never get used. About 11 are blocked by the robber, 11 discarded on a 7, 8 stolen, and 4 taken by Monopoly. The chance of holding more than 7 cards at the end of a turn rises from 5% at round 2 to 21% at round 20, so holding cards gets riskier as the game goes on.
- **Not converting.** The *hoarder* style produces as much as *balanced* but trades least, discards most (8.6 cards per game), and wins 24.7% against 32.3%. Cards sitting in a hand are worth nothing until they are built.
- **Being boxed in.** Over half of players (58%) are still on their two starting settlements at round 10. Without a third spot, production stays where the opening put it.

The game also pushes back against the leader. When a player steals with the robber, they pick the points leader 77% of the time, against 50% at random. Many players also refuse to trade with someone close to winning. Both slow the leader down, which is part of why early leads are fragile.

4.5 Trading in the middle game

Player-to-player trading peaks around round 10, at about 0.9 trades per round. After that, trading with the bank takes over. Trading is how players fix a one-sided start, and it helps everyone. Without player trading, games take 14% longer and players discard 37% more. But on any single trade, the player who asks usually pays a small premium for getting what they need now.

5 The endgame, and what the search bot does

> IN SHORT
> The ideas from the opening and middle game carry through. The player whose ore-and-wheat engine produces the most reaches 8 points first and usually wins about two rounds later. The last points come from cities, a hidden victory-point card, and one bonus award. A search bot that plans ahead wins more by placing roads better, timing knights, and refusing trades that help the partner more.

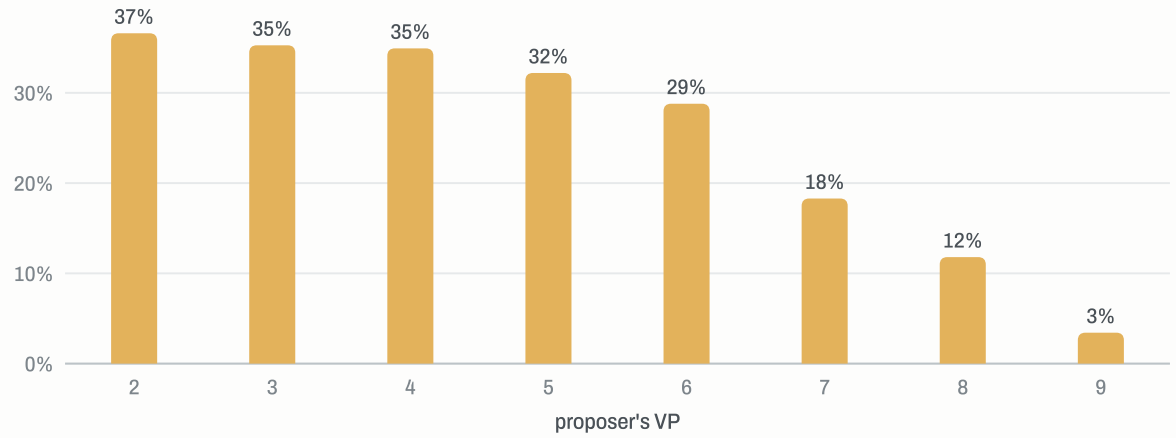
5.1 The race from 8 points

The first player to show 8 public points wins 62.8% of games, typically about 2.1 rounds later. The last two points rarely come from a new settlement, because most spots are taken by then. They come from a city, an award, or a hidden victory-point card. Three in four winners (74%) finish holding at least one victory-point card that the others could not see.

The rest of the table pushes back on a leader. From 7 points on, other players' trade refusals start to matter. A proposer at 7 VP gets 18% of offers through, at 8 VP 12%,

and at 9 VP 3% (Figure 12). The leader turns to the bank instead, which costs time but rarely stops them.

Figure 12. Share of trade offers accepted, by the proposer's points



econ_base20k. Bots refuse to trade with a player near the win.

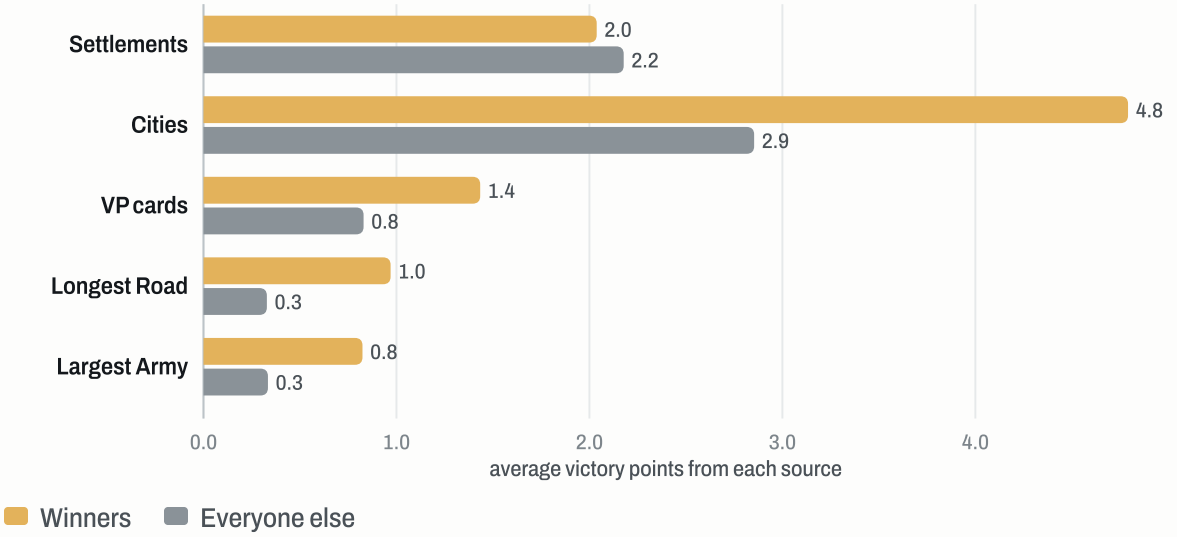
5.2 Where winners' points come from

Winners average 10.1 points and the others 6.5 (Figure 13). The difference of 3.5 points comes from:

- cities, +1.9 points (2.4 cities against 1.4)
- Longest Road, +0.6
- victory-point cards, +0.6
- Largest Army, +0.5

Settlements are about the same for both groups (2.0 against 2.2), because winners upgrade theirs into cities. That is the opening's ore-and-wheat preference, paying out at the end.

Figure 13. Sources of victory points at game end



Winners have more cities and more bonuses, not more settlements. baseline_4p, 100,000 games. Settlements are counted after upgrades.

The two awards are close to decisive (Table 5). A player holding Longest Road alone wins 45.5% and Largest Army alone 40.2%. The rare player holding both wins 91%. Without either, a player wins only 8.3%, and only 18% of winners manage without one.

Table 5. The two awards at game end

Holds	Share of players	Win rate	Share of winners
Longest Road only	22.3%	45.5%	41%
Largest Army only	20.6%	40.2%	33%
Both	2.2%	91.2%	8%
Neither	54.9%	8.3%	18%

The Monopoly card is an endgame weapon. Hands are biggest late in the game, so a Monopoly takes more then: about 6 cards in rounds 1–5 against 7.4 in rounds 21–30.

Holding the card until it will take 7 or more is worth about +3 points against playing it early for a small haul.

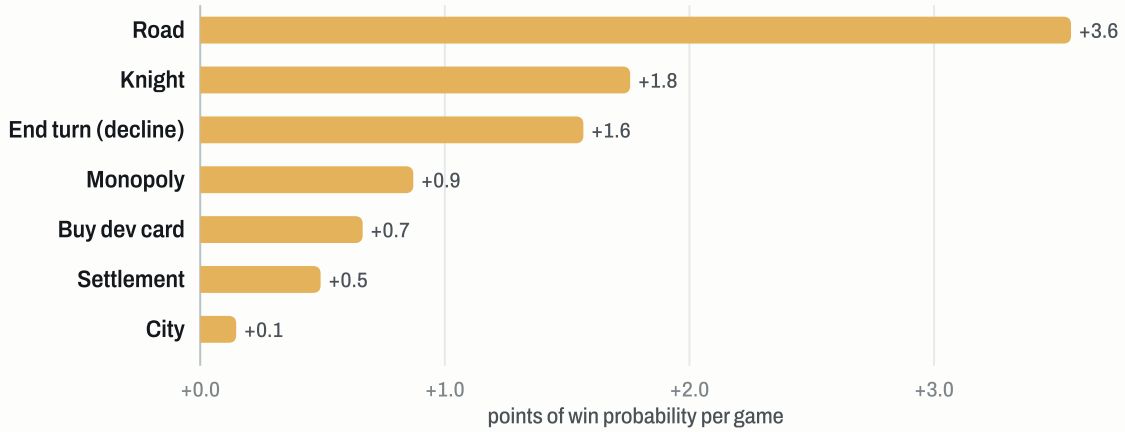
5.3 What the search bot prioritizes

The strongest player here is a Monte Carlo tree search (MCTS) bot. At each decision it tries the legal moves, plays each forward many times with simulated opponents, and scores the outcome with a learned value model. Its main rival is the best rule-based bot, tuned by evolution, which already beats the balanced style by about 9.6 points.

Over 600 paired games, MCTS beats the tuned bot by +7.2 points (95% CI 2.5–11.7). A decision-by-decision attribution, which credits each point where the two bots would choose differently, puts the edge at +9.1 points (7.6–10.6).

MCTS disagrees with the tuned bot only about 3.2 times in a game of roughly 126 decisions. In a typical game, two of those decisions account for 80% of the swing. Strong play here is mostly about recognizing the few moments that matter.

Figure 14. Where the search bot gains, by the move it chose instead

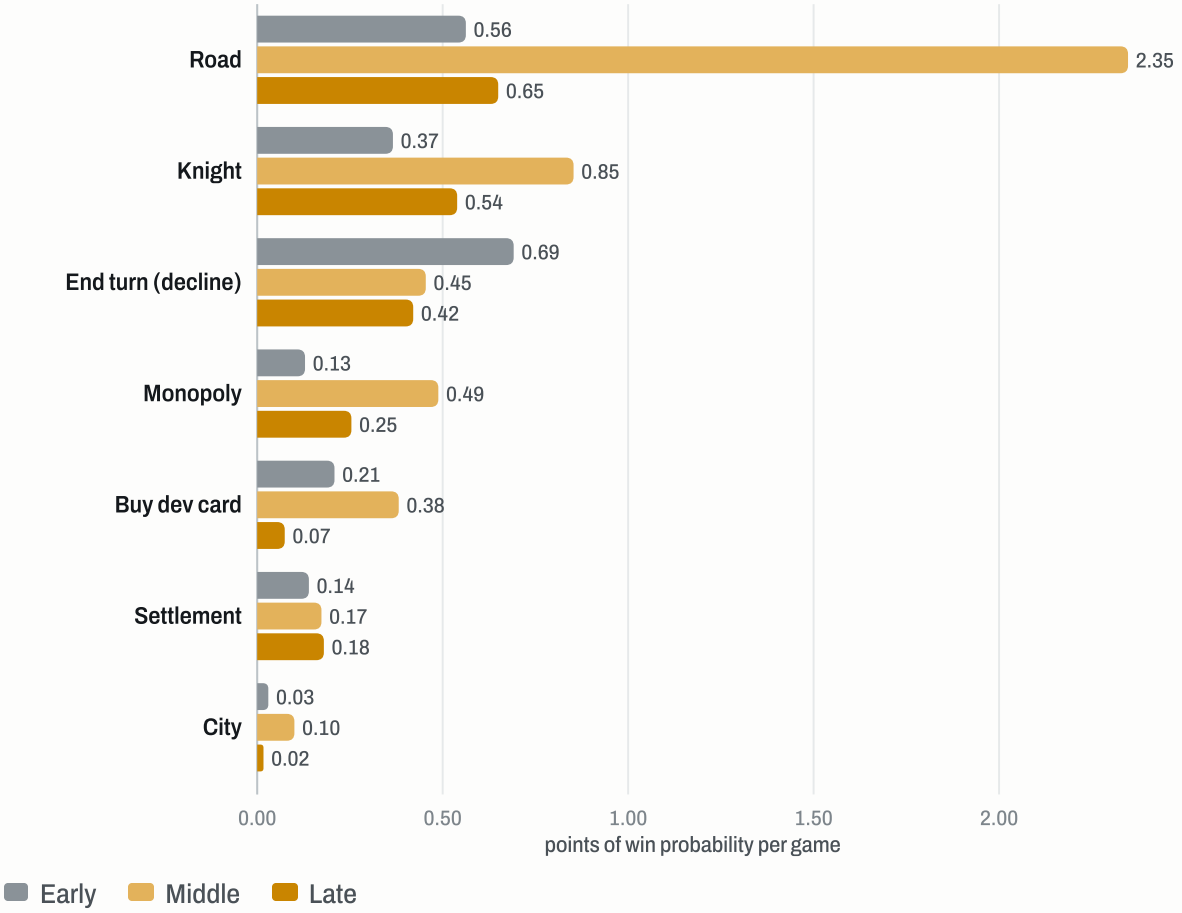


Roads, knights, and saying no. Points of win probability per game credited to decisions where MCTS chose this move and the tuned bot chose something else (600 games). Hover for how often it happens and the share of those decisions that helped.

Its priorities, in order of the value they add:

- **Roads, placed with a plan** (+**3.6 points per game**). This is the biggest gain by far. The largest single gain is building a road somewhere *better* than where the tuned bot would have, toward a contested spot or a longer Longest Road (+1.4, helpful 71% of the time). MCTS also builds roads where the tuned bot would trade or settle elsewhere. Two thirds of the road gain comes in the middle game.
- **Knights at the right moment** (+**1.8**). MCTS often plays a knight where the tuned bot would propose a trade. That moves the robber off its own hex, steals from the leader, and builds toward Largest Army. These decisions help 85% of the time.
- **Saying no** (+**1.6**). Most of MCTS's disagreements (2 per game) are cases where it ends the turn instead of making the trade the tuned bot would make. Each refusal is worth little and wins only half the time. Together they add up, because they keep the partner from getting what they need.
- **Timing Monopoly and development cards** (+**0.9 and** +**0.7**). MCTS plays Monopoly when the haul is large and buys development cards when the deck still has knights to give.
- **Settlements and cities** (+**0.5 and** +**0.15**). Here it agrees with the tuned bot. Building on good spots and upgrading to cities is already handled well by simple rules.

Figure 15. The search bot's gains by game stage



The middle game is where search pays. The same attribution split by game stage. The middle game gives 4.8 points per game, and the early and late stages 2.1 each. By position, MCTS gains most when behind (3.7) and less when level or ahead (2.7 each).

Table 6. The search bot's most valuable disagreements

Tuned → MCTS	Per game	Points	95% CI	Helped
Road → Road	0.14	+1.39	0.81 – 2.10	71%
Propose trade → End turn (decline)	1.32	+0.77	0.26 – 1.27	49%
Propose trade → Knight	0.09	+0.74	0.45 – 1.05	85%
Propose trade → Road	0.16	+0.69	0.27 – 1.19	56%
Settlement → Road	0.10	+0.56	0.23 – 0.93	63%
Bank trade → Road	0.04	+0.46	0.15 – 0.89	87%
Propose trade → Monopoly	0.06	+0.44	0.14 – 0.82	66%
Propose trade → Buy dev card	0.04	+0.39	0.17 – 0.66	87%
Bank trade → End turn (decline)	0.24	+0.39	0.10 – 0.70	54%
Buy dev card → Knight	0.03	+0.31	0.12 – 0.56	84%

"Tuned → MCTS" is what the tuned bot would do and what MCTS did instead. Points are win probability per game, with a 95% CI from resampling games. "Helped" is the share of those decisions with a positive effect.

Put together, the search bot plays the same game this paper describes. It values the road to the next good spot, uses the robber against the leader, and trades only when the trade helps it more than the partner. It leaves the opening and city-building to the rules that already work.

5.4 Putting it together

1. **Open on pips**, preferring ore and wheat, and cover as many of the five resources as you can. Treat 6s and 8s as pips, not magic.
2. **Play your seat.** First seat: take the ore-and-wheat spot, since your second pick comes last. Last seat: choose your two spots as a matched pair.

3. **Build the engine.** Get a city up and a third settlement down. Spend cards instead of holding them, and trade or use a port to fix what your start lacks.
4. **From round 10, stay within a point of the leader** and keep a development card or two in hand.
5. **Close with cities and one award.** Hold a hidden victory-point card if you can, and save Monopoly for a big haul.
6. **Watch for the few decisions that matter**: where a road leads, when to play a knight, and when to turn down a trade.

6 Caveats

- **Bots, not people.** People bluff, form alliances, and trade more freely with friends. The size of each effect reflects how these bots play, but the direction mostly follows from the rules and the board, and should carry over.
- **Associations, not always causes.** The placement findings come from regressions on 100,000 games and from placement labs that fixed the position and varied only the choice. The middle-game snapshot is descriptive: production at round 10 is partly luck.
- **Hidden hands.** Most runs let bots see opponents' hands. Replays with hidden hands changed no style's win rate by more than a point, and the MCTS games were played with hidden hands.
- **Base game only.** The expansions and 5–6 player boards are not modelled.

Source: catan/analysis/gameflow.py, catan/analysis/market.py and reports/econ_paper/build_strategy.py / build_data.py. Every number in the text comes from strategy_data.json and paper_data.json, embedded in this page.