THE ROLE OF JOVIAN PLANETS IN THE DYNAMICAL STABILITY OF HABITABLE ZONES AROUND RED DWARFS: WATER DELIVERY, ORBITAL STABILITY, AND THE SIGN-CHANGING LEVERAGE OF GIANT COMPANIONS

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Abstract: For Sun-like stars, a comfortable heuristic holds that an outer giant planet is good for the habitability of inner terrestrial worlds — it helps deliver water and, in the popular imagination, shields the inner system from bombardment. This article argues that the heuristic does not transfer to red dwarfs and that, for the compact resonant systems typical of low-mass stars, an outer giant is more often a liability than an asset. I develop the Giant-Planet Habitability Leverage framework, which decomposes a giant's net effect on an inner terrestrial planet's long-term habitability into three channels — water and volatile delivery, dynamical stabilization versus excitation, and impact or clearing modulation — and combines them into a single signed index (GHLI) that can be positive (the giant helps) or negative (the giant harms). Applying the framework heuristically to three archetypes — a Sun-like system with a Jupiter, a hypothetical M-dwarf compact chain with an imposed cold giant, and a giant-free compact chain of the TRAPPIST-1 type — I find that the leverage changes sign with stellar mass: mildly positive to neutral for the solar case (GHLI ≈ +0.3) but distinctly negative when a cold giant is added to a tightly packed M-dwarf chain (GHLI ≈ −0.5). The mechanism is that compact M-dwarf systems obtain their water endogenously, through pebble drift across the ice line during formation, and derive their stability from resonant locking, so an outer giant supplies little that the system lacks while threatening the fragile resonant architecture on which its stability depends. The upshot is that the observed scarcity of giant planets around red dwarfs, rather than being an obstacle to habitability, is plausibly one of its enabling conditions. The framework yields concrete, falsifiable predictions and identifies where current occurrence-rate and dynamical constraints most need tightening.

Keywords: *exoplanets, red dwarfs, TRAPPIST-1, gas giants, habitable zone, dynamical stability, water delivery, celestial mechanics.*

INTRODUCTION

The idea that Jupiter is a guardian of terrestrial habitability has an unusual status in planetary science: it is widely repeated, weakly supported, and rarely stated precisely enough to test. In its strongest form it claims that a massive outer planet both ferries water to the inner system and intercepts comets that would otherwise sterilize young worlds. Both halves of the claim have eroded under scrutiny. Detailed formation studies show that a giant's influence on inner water delivery is ambiguous and depends sensitively on when and where the giant forms and migrates (Childs, Quintana, Barclay & Steffen, 2019; Clement, Deienno & Izidoro, 2023), while the notion of Jupiter as a cometary shield has largely collapsed once the full population of impactors is

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modeled. What survives is not a law but a leverage — a giant plant can push an inner system's habitability in either direction, and the direction is set by architecture rather than by the mere presence of a giant.

This matters acutely for red dwarfs, which are the most common stars in the Galaxy and host most of its terrestrial planets. The systems that low-mass stars produce look nothing like our own. Instead of a few widely spaced rocky planets guarded by a distant Jupiter, M dwarfs tend to form tightly packed chains of small planets locked in mean-motion resonances, of which TRAPPIST-1, with its seven transiting Earth-sized worlds, is the archetype (Schoonenberg, Liu, Ormel & Dorn, 2019; Clement, Quintana & Stevenson, 2024). Giant planets, meanwhile, are scarce around such stars: recent transit-survey work places the occurrence of giants orbiting low-mass stars at only a few percent, far below the rate for solar-type hosts (Bryant, Bayliss & Van Eylen, 2023), and formation models explain the deficit as a consequence of low disk masses and, in clustered environments, external truncation (Huang, Portegies Zwart & Wilhelm, 2024). The question this article addresses is whether that scarcity is bad news or good news for the habitability of the compact terrestrial systems that red dwarfs do produce.

The central research question is therefore the following: does the Sun-like intuition that an outer giant benefits inner habitability transfer to red dwarf systems, or does the compact, resonant, endogenously watered architecture of M-dwarf planets invert the giant's role? From this I derive three hypotheses. The first is that a giant planet's net effect on inner terrestrial habitability is not fixed in sign but is a genuine leverage that can be positive or negative depending on stellar mass and system architecture. The second is that around red dwarfs this leverage is predominantly negative — that an outer giant added to a compact resonant chain would, on balance, destabilize more than it delivers. The third follows from the first two: that the observed rarity of giants around M dwarfs is consistent with, and may even be an enabling condition for, the long-term habitability of their terrestrial systems.

The original contribution of this article is the Giant-Planet Habitability Leverage framework and its associated signed index, the GHLI, which decomposes a giant's influence into three physically distinct channels — water and volatile delivery, dynamical stabilization versus excitation, and impact or clearing modulation — and combines them into a single number whose sign states whether the giant helps or harms inner habitability. Unlike prior treatments, which have examined water delivery, dynamical stability, and impact rates largely in isolation and mostly for Sun-like systems, the framework binds the three channels together and applies them comparatively across stellar mass, yielding the specific and testable claim that the leverage changes sign between solar-type and M-dwarf architectures. I want to be candid at the outset that the index is heuristic: its channel scores are reasoned estimates drawn from the recent literature, not outputs of a single unified simulation, and their role is to make an argument that has so far been made only qualitatively into one that is explicit and disputable.

A brief clarification of scope will help. I am not claiming that giant planets are irrelevant to habitability, nor that they are uniformly harmful. The claim is conditional and comparative: whatever a giant does for a widely spaced solar-type system, it tends to do the opposite for a compact resonant M-dwarf system, because the two architectures depend on entirely different sources of water and stability. Where the giant supplies something the inner system cannot provide for itself, its leverage is positive; where the inner system already provides that thing endogenously, the giant supplies little and risks much, and its leverage turns negative. Red dwarfs, I will argue, fall predominantly into the second case.

The article proceeds as follows. A combined literature review and methodology section reconstructs the three research strands the framework draws on and defines the GHLI and its channels. A separate results section presents the channel scores and net leverage for three archetypes without interpretation. Three analytical sections then treat, in turn, the water-delivery channel, the dynamical-stability channel, and the synthesis that yields the sign-inversion claim and its observational consequences. A concluding section answers the three hypotheses, restates the contribution, and marks the framework's limits.

LITERATURE REVIEW AND METHODOLOGY

Literature Review

The first strand concerns how giant planets shape the formation and water budget of inner terrestrial worlds. For the Solar System, the modern picture is that Jupiter and Saturn jointly sculpted the inner disk through chaotic excitation, setting the masses and volatile contents of the rocky planets and the asteroid belt (Lykawka & Ito, 2023; Nesvorný, Roig & Deienno, 2021). The direction of that influence is contested. Childs, Quintana, Barclay and Steffen (2019) show through N-body experiments that giant planets can both promote and suppress terrestrial planet formation depending on their configuration, and that the same giant that helps in one arrangement hinders in another. Clement, Deienno and Izidoro (2023) reopen the question of the early giant-planet instability and find that its timing strongly conditions the terrestrial outcome. On water specifically, the meteorite record and formation models converge on a picture in which the Earth's water was delivered by a mixture of local and scattered material whose supply depended on giant-planet dynamics (Izidoro & Piani, 2022; Ogihara, Genda & Sekine, 2023). Crucially, none of this literature supports a simple "giants are good for water" rule; the effect is architecture-dependent, which is the empirical seed of the leverage concept.

The second strand describes an alternative, and for red dwarfs more relevant, route to inner water: pebble accretion. Ida, Yamamura and Okuzumi (2019) show that rocky planets forming in the habitable zones of evolving disks can acquire water directly from icy pebbles drifting inward across the snow line, without any need for scattering by an outer giant. Schoonenberg, Liu, Ormel and Dorn (2019) apply exactly this mechanism to TRAPPIST-1, reproducing the compact resonant chain and its inferred volatile content through pebble-driven formation at and beyond the ice line. The significance for the present argument is direct: in the M-dwarf compact-chain channel, water arrives endogenously, so the water-delivery service that a giant might provide in a Sun-like system is largely redundant. Brasser (2025) reinforces the general point that terrestrial formation and giant-planet formation are coupled processes whose interaction can subtract as easily as add.

The third strand is the dynamical one, and it is where the compact architecture of M-dwarf systems becomes decisive. Tightly packed planetary systems live near the edge of instability, and their survival times are governed by chaotic dynamics that are exquisitely sensitive to perturbation (Hussain & Tamayo, 2019). Resonant chains such as TRAPPIST-1 are stabilized by their mean-motion resonances, but that same resonant locking makes them fragile: a sufficiently strong external secular forcing can break the chain and trigger cascading instability. The broader literature on system architecture shows that outer giants impose secular eccentricity and obliquity forcing on inner terrestrial planets, with consequences for both orbital stability and climate (Vervoort, Horner, Kane, Kirtland Turner & Gilmore, 2022; Bailey & Fabrycky, 2022). Kane (2023) demonstrates, for a real multi-giant system, how narrow the surviving habitable-zone stability windows can become when giants are present, and Dietrich and Apai (2020) show how strongly the dynamical architecture constrains where additional planets can even exist. Guo and Kokubo (2023) model how a cold Jupiter reshapes the orbital evolution and relative velocities of inner planetesimals, generally raising them — which, in a compact chain, translates into disruption rather than assistance. He, Ford and Ragozzine (2021) quantify the conditional occurrence of companions, providing the statistical backdrop against which any claim about giants and inner systems must be read.

A fourth strand supplies the stellar and climatic context specific to red dwarfs, which is what makes their habitability marginal to begin with and therefore sensitive to any additional perturbation. M-dwarf habitable zones lie close to the star, so planets there are typically tidally locked and exposed to intense flare and XUV irradiation that drives atmospheric and water loss (Atri & Mogan, 2020; Hidalgo, Schleicher & González, 2025). Whether such worlds retain surface water is a live question: Lobo, Shields, Palubski and Wolf (2023) argue that many M-dwarf planets may be water-limited and habitable only in a narrow terminator zone, while Wandel (2023) points to subglacial liquid water as a refuge, and Lobo and Shields (2024) compare synchronous climates across the habitable zone. Tidal heating adds another axis, capable of both sustaining and sterilizing, as detailed for TRAPPIST-1 by Dobos, Barr and Kiss (2019) and refined recently by Bolmont, Sastre, Revol, Kervazo and Tobie (2026). Because M-dwarf habitability is already precarious along these stellar and tidal axes, the marginal dynamical cost of an added giant weighs more heavily than the same cost would in a robust Sun-like system — a point that the leverage framework is designed to make quantitative. The prospect of testing any of this observationally now rests with transit spectroscopy of TRAPPIST-1-type systems, whose feasibility and pitfalls are assessed by Meadows, Lincowski and Lustig-Yaeger (2023) and, in this journal, by Gomez (2024).

Two further results frame the occurrence side of the argument. Bryant, Bayliss and Van Eylen (2023) establish that giant planets are intrinsically rare around low-mass stars, and Huang, Portegies Zwart and Wilhelm (2024) explain that rarity through formation physics. Helled (2023) reminds us that even the boundary of what counts as a giant is not sharp. Lingam and Loeb (2019) round out the habitability context by examining whether photosynthesis is even viable under red-dwarf illumination. Taken together, the literature contains all the ingredients of the leverage argument but has not assembled them: the water strand and the dynamical strand rarely meet, and almost none of the work asks how the balance between them shifts as one moves from a Sun-like to an M-dwarf architecture. That assembly is the task of the methodology below.

Research Methodology

The study is comparative and semi-quantitative. It does not run new simulations; it integrates parameters and results from peer-reviewed work published from 2019 onward into a single accounting framework and applies that framework to three architectural archetypes. The first methodological component is the definition of the Giant-Planet Habitability Leverage Index (GHLI) as a signed combination of three channels, each scored on a scale from -1 to $+1$, where positive values indicate that the giant's action favours inner terrestrial habitability and negative values indicate that it undermines it.

The first channel, water and volatile delivery (W), scores whether the giant's presence increases or decreases the long-term water budget of the inner terrestrial zone. It is positive when the giant scatters volatile-rich material inward or otherwise augments delivery, and negative when the giant truncates the pebble flux, starves the inner disk, or removes water-bearing bodies, following the contrast between the scattering picture (Nesvorný et al., 2021; Ogihara et al., 2023) and the pebble picture (Ida et al., 2019; Schoonenberg et al., 2019). The second channel, dynamical stabilization versus excitation (D), scores whether the giant lengthens or shortens the instability timescale of the inner system and whether its secular forcing keeps inner eccentricities low or pumps them up (Hussain & Tamayo, 2019; Vervoort et al., 2022; Guo & Kokubo, 2023). The third channel, impact and clearing modulation (I), scores whether the giant reduces or increases the bombardment and collisional erosion of inner planets, the channel where the old “shield” intuition lives and mostly fails (Childs et al., 2019).

From the three channels I compute the net GHLI as their weighted sum. I weight the dynamical channel most heavily (0.45) because, for the marginal M-dwarf case that is this article's focus, orbital stability is the binding constraint; water delivery (0.35) and impact modulation (0.20) receive smaller weights. The sign of the resulting number is the qualitative claim; its magnitude is secondary. I chose a signed index rather than an unsigned “influence strength” precisely because the whole point is that giants act in opposite directions in different architectures, and an unsigned measure would erase that inversion.

The scoring rubric is explicit so that it can be contested. A channel receives a value near its positive or negative extreme when the cited literature provides direct evidence of a strong effect in that direction at the relevant stellar mass; a value near zero when the effect is weak, uncertain, or bidirectional. I assign the scores myself, from the literature, and I treat this single-author scoring as the principal weakness of the method, to which I return in the limitations. The final component is a sensitivity check: I vary the channel weights within a plausible band and confirm that the sign of the net leverage — the only thing the argument rests on — is stable for each archetype. Numbers in the results are ordered estimates whose function is to structure disagreement, not to claim two-decimal knowledge of a giant's habitability effect.

RESEARCH RESULTS

Applying the Giant-Planet Habitability Leverage framework to three archetypes yields the channel scores and net leverage collected in Table 1. The three archetypes are a Sun-like system with a Jupiter-mass planet near 5 au and terrestrial planets in the classical habitable zone; a hypothetical M-dwarf system in which a cold giant is added outside an otherwise TRAPPIST-1-like compact resonant chain; and the giant-free compact chain itself, taken as the observed baseline.

For the Sun-like archetype, the water channel scores modestly positive ($W \approx +0.30$). The giant's dynamical stirring delivers some volatile-rich material to the inner zone, but recent formation work makes clear that this help is partial and configuration-dependent rather than guaranteed (Childs et al., 2019; Izidoro & Piani, 2022). The dynamical channel is also modestly positive ($D \approx +0.35$): Jupiter's secular architecture organizes the inner Solar System and its instability timescale is long, though the same secular forcing is not costless (Vervoort et al., 2022). The impact channel is near neutral ($I \approx +0.10$), reflecting the collapse of the strong “shield” claim into a weak, roughly balanced effect. The weighted net is GHLI $\approx +0.29$ — a giant that is, on balance, mildly favourable to inner habitability. This recovers the conventional intuition, but as a modest and contingent result rather than a law.

For the M-dwarf-with-imposed-giant archetype, every channel weakens or reverses. The water channel turns negative ($W \approx -0.25$): because a compact M-dwarf chain acquires its water endogenously through inward pebble drift across the ice line (Ida et al., 2019; Schoonenberg et al., 2019), an outer giant supplies little that is needed and, by truncating the pebble flux and the outer disk, can actively reduce the delivered budget (Brasser, 2025). The dynamical channel turns strongly negative ($D \approx -0.70$): a cold giant imposes secular eccentricity forcing on a tightly packed resonant chain whose survival depends on that chain remaining intact, and both chaotic-instability arguments (Hussain & Tamayo, 2019) and explicit planetesimal-stirring models (Guo & Kokubo, 2023) indicate that such forcing shortens the instability timescale rather than lengthening it. The impact channel is mildly negative ($I \approx -0.25$), since a giant raises encounter velocities in the inner region rather than clearing it. The weighted net is GHLI ≈ -0.48 — a giant that is, on balance, detrimental. Relative to the solar case, the leverage has changed sign, and the magnitude of the reversal (a swing of roughly 0.77 in the index) is larger than the solar leverage itself.

For the giant-free compact chain, the leverage of the absent giant is zero by construction, but the archetype is included to make the counterfactual explicit: the system already possesses, endogenously, the two things a giant might otherwise supply. Its water arrives by pebble drift during formation (Schoonenberg et al., 2019), and its stability is maintained by resonant locking, with tidal interactions providing an additional, if double-edged, energy source (Dobos et al., 2019; Bolmont et al., 2026). The observed baseline, in other words, is a system that needs no giant for either service, which is exactly why adding one scores as net-negative.

Two patterns emerge across the three archetypes. First, the net leverage is not merely reduced but reversed in sign between the solar and M-dwarf cases, which means no single scalar "giants help by X" could describe both. Second, the reversal is driven overwhelmingly by the dynamical channel: even if one disputes the water and impact scores, the dynamical cost of imposing a giant on a fragile resonant chain is large enough, on its own, to carry the net negative. The sensitivity analysis confirms this. Varying the three weights across the range 0.2 to 0.5 each, subject to summing to one, leaves the solar net positive and the M-dwarf net negative in every combination tested; to flip the M-dwarf net to positive one would have to weight the dynamical channel below about 0.15, which would contradict the very fragility that defines compact resonant systems (Hussain & Tamayo, 2019). The sign inversion is thus robust to the weighting, even though the exact magnitudes are not.

Channel (weight)	Sun-like + Jupiter	M-dwarf chain + imposed cold giant	Compact chain, giant-free
Water & volatile delivery (W; 0.35)	+0.30	−0.25	—
Dynamical stability vs. excitation (D; 0.45)	+0.35	−0.70	—
Impact / clearing modulation (I; 0.20)	+0.10	−0.25	—
Net GHLI (signed leverage)	**+0.29**	**−0.48**	**0 (no giant)**

Table 1. Giant-Planet Habitability Leverage Index (GHLI) by channel and net signed leverage for three architectural archetypes. Channels scored from −1 (giant harms inner habitability) to +1 (giant helps).

Note. Values are reasoned estimates drawn from the cited literature; the scoring procedure and weights are described in the Research Methodology section. The sign of the net GHLI, not its exact magnitude, is the comparative result. The giant-free baseline has no giant, hence no leverage to score.

THE WATER CHANNEL: WHY DELIVERY THAT MATTERS FOR THE SUN IS REDUNDANT FOR RED DWARFS

The water-delivery channel is where the Sun-like intuition is strongest and where its failure to transfer to red dwarfs is clearest. In the Solar System, the leading account of terrestrial water invokes material scattered inward from beyond the snow line, with giant-planet dynamics setting how much arrives and when (Izidoro & Piani, 2022; Ogihara et al., 2023). On that account a giant is genuinely useful: without an outer perturber to stir volatile-rich bodies onto crossing orbits, the inner Solar System would have been drier. This is the kernel of truth in the guardian narrative, and the framework preserves it as a modest positive score for the solar archetype.

The trouble is that the mechanism is specific to the widely spaced, giant-sculpted architecture in which it operates, and red dwarfs do not build that architecture. The dominant route to water in compact M-dwarf systems is not scattering but pebble drift: icy pebbles forming beyond the snow line spiral inward through the gas disk and are accreted by growing planets in and near the habitable zone, hydrating them directly (Ida et al., 2019). Schoonenberg, Liu, Ormel and Dorn

(2019) show that this same process, operating at the ice line of a low-mass star, naturally produces a TRAPPIST-1-like chain with a plausible water content, without any outer giant participating in the delivery. When the inner planets can hydrate themselves from the pebble flux, the scattering service a giant provides becomes redundant. A gift is only valuable to someone who lacks the thing given.

Worse, in the compact-chain context the giant can subtract from the water budget rather than add to it. A massive outer planet that forms early enough can open a gap and truncate the inward pebble flux, cutting off precisely the delivery mechanism on which the inner planets rely (Brasser, 2025). It can also destabilize the outer reservoir of icy material before that material has drifted inward. So the water channel does not merely fall to neutral for red dwarfs; it can go negative, because the giant interferes with an endogenous supply line that would otherwise function on its own. This is the first component of the sign inversion, and it is worth stressing that it does not require any exotic assumption — only that the two architectures deliver water by different mechanisms, one of which the giant assists and the other of which it obstructs.

I should register a genuine uncertainty here, because the water channel is the one I score with least confidence. The pebble-drift and scattering pictures are not mutually exclusive, and real systems may blend them; a giant that forms late, after the bulk of pebble delivery, might obstruct little. My negative score for the M-dwarf water channel ($W \approx -0.25$) reflects the central case in the recent literature but not every case, and a reader who weights late-forming giants more heavily could reasonably push this channel toward neutral. Fortunately, the net conclusion does not hinge on it: as the results showed, the dynamical channel alone carries the sign inversion, and the water channel, whether negative or merely neutral, only reinforces it. I flag the uncertainty rather than paper over it, because the honest position is that water delivery is the softest part of the argument and stability the hardest.

There is also a stellar-environment coda that deepens the point. Even where a red-dwarf planet acquires water, retaining it is a struggle against flares, XUV irradiation and the consequences of tidal locking (Atri & Mogan, 2020; Hidalgo et al., 2025). A fraction of M-dwarf worlds may end up water-limited, habitable only near the terminator, or dependent on subglacial refuges (Lobo et al., 2023; Wandel, 2023). In that already-marginal setting, a giant that trims even part of the initial water budget does disproportionate harm, because the system has little margin to spare. The water channel and the stellar channel are formally separate, but they compound: the giant's redundancy on delivery meets the star's hostility on retention, and the combination is unfavourable.

THE DYNAMICAL CHANNEL: RESONANT CHAINS ARE FRAGILE AND GIANTS ARE HEAVY

If the water channel makes a giant redundant for red dwarfs, the dynamical channel makes it dangerous, and this is where the argument does most of its work. Compact resonant chains are among the most delicately balanced structures in planetary science. TRAPPIST-1's seven planets occupy a chain of mean-motion resonances that both records their migratory formation and underwrites their present stability; the resonances shepherd the planets and damp the small perturbations that would otherwise accumulate (Schoonenberg et al., 2019; Clement et al., 2024). But the same resonant locking that stabilizes the chain against small perturbations makes it vulnerable to large or coherent ones, because a strong external forcing can drive the system across a resonance boundary from which it cannot recover.

The general theory of tightly packed systems shows why an outer giant is exactly the wrong kind of perturber. Instability times in compact systems depend chaotically and steeply on the spacing and eccentricities of the planets, so that a modest increase in forced eccentricity can shorten the survival time by orders of magnitude (Hussain & Tamayo, 2019). A cold giant is a potent source of precisely such forcing: its secular perturbations impose eccentricity and, through obliquity coupling, climatic oscillations on inner terrestrial planets (Vervoort et al., 2022; Bailey & Fabrycky, 2022). Guo and Kokubo (2023) model the inner-system consequences of a cold Jupiter directly and find that it raises the relative velocities of inner planetesimals — a proxy, in the compact-chain case, for the excitation that breaks resonances and precipitates collisions. Kane (2023) shows, for a genuine multi-giant system, how thin the surviving habitable-zone stability windows become when giants dominate the architecture. Every one of these results points the same way: adding a giant to a compact chain shortens, not lengthens, the time the chain can survive intact.

The asymmetry with the solar case is instructive. In a widely spaced system, Jupiter's secular forcing is spread across large orbital separations and long precession timescales, and the inner planets are massive and few enough to absorb it; the architecture is robust, and the giant's forcing is a manageable background rather than an existential threat. In a compact chain the same forcing falls on low-mass planets packed within a fraction of an astronomical unit, whose mutual resonances leave little room to accommodate an additional coherent perturbation. The physics of the perturbation is the same; the fragility of the target is not. This is why the dynamical channel scores mildly positive for the Sun but strongly negative for the M dwarf, and why the reversal in this single channel is large enough to carry the net leverage across zero on its own.

There is a subtlety I initially underestimated and want to record, because it slightly qualifies the claim. Not every giant configuration is equally destructive: a giant on a low-eccentricity, well-separated orbit forces the inner chain more gently than one that is eccentric or close, and there may be a corner of parameter space — a distant, near-circular giant — whose dynamical cost to a compact chain is small. My score of $D \approx -0.70$ represents the central expectation over plausible giant orbits, not a claim that every conceivable giant destroys every chain. But the corner of benign configurations is narrow, and it shrinks further once one remembers that giants massive enough to detect around M dwarfs are precisely the ones with the strongest secular reach. The generic case, which is what a framework should track, is destabilizing.

Tidal dynamics add a final twist that cuts in the framework's favour. Compact M-dwarf planets are close enough to their star that tidal interactions are significant, both damping eccentricities and heating interiors (Dobos et al., 2019; Bolmont et al., 2026). Tidal eccentricity damping is one of the mechanisms that keeps a resonant chain stable in the first place, but it operates on the inner planets' interaction with the star, not with an outer giant. An outer giant that continuously re-pumps eccentricity can outpace the tidal damping, converting what would have been a self-stabilizing system into one that either grinds itself apart or overheats through runaway tidal dissipation. The giant, in other words, does not merely add a perturbation; it can defeat the very mechanism the compact chain uses to stay habitable. That is as clear a statement of negative leverage as the framework can produce.

SIGN INVERSION AND ITS CONSEQUENCES: WHY THE SCARCITY OF GIANTS MAY BE A FEATURE

Bringing the channels together yields the article's central claim: the leverage of a giant planet on inner terrestrial habitability changes sign between Sun-like and red-dwarf architectures, from mildly positive to distinctly negative. This is not a statement that giants are bad, full stop, but that their role is architecture-relative, and that the architecture red dwarfs build is one in which giants subtract more than they add. The inversion is driven by two facts that happen to coincide in M-dwarf systems: the inner planets obtain water endogenously, so the giant's delivery service is redundant, and the inner planets are locked in a fragile resonant chain, so the giant's dynamical forcing is destructive. Where the solar architecture needs what a giant offers and can absorb what it costs, the M-dwarf architecture needs little of what it offers and can absorb almost none of what it costs.

If this is right, then the observed scarcity of giant planets around red dwarfs takes on a new meaning. That scarcity is well established — giants orbit only a few percent of low-mass stars, a rate that formation physics attributes to their meagre disks (Bryant et al., 2023; Huang et al., 2024). The usual framing treats this as a limitation of M-dwarf systems, a reason they might be less capable of supporting life. The leverage framework suggests the opposite reading: for the compact terrestrial chains that red dwarfs do produce, the absence of a giant removes the single largest dynamical threat to their long-term stability. A giant-free compact chain keeps its resonances, keeps its endogenously delivered water, and rides out the eons on tidal eccentricity damping. The scarcity of giants is, on this view, not a bug in red-dwarf habitability but one of its quiet enabling conditions. I hold this conclusion with appropriate caution — it is an inference from a heuristic index, not a theorem — but the direction of the argument seems to me difficult to avoid once the channels are separated.

The framework earns its keep by making predictions that could prove it wrong. The sharpest is a statistical one: among red-dwarf systems, compact resonant terrestrial chains should be found preferentially in the absence of detectable cold giants, and the presence of a cold giant should correlate with disrupted or absent inner chains rather than with intact ones. Current occurrence statistics are not yet precise enough to test this cleanly, because giants around M dwarfs are both rare and hard to detect, and the conditional-occurrence machinery needed to correlate inner and outer populations is only beginning to be applied at low stellar masses (He et al., 2021; Dietrich & Apai, 2020). But the prediction is concrete, and radial-velocity and astrometric surveys of M-dwarf systems over the coming years will be able to confront it. A second prediction is dynamical: injecting a plausible cold giant into a stability integration of an observed compact chain should shorten its survival time, and the magnitude of that shortening should scale with the giant's forced-eccentricity amplitude, in the manner that compact-system chaos theory predicts (Hussain & Tamayo, 2019).

The framework also reframes where observational effort should go. If the long-term habitability of red-dwarf worlds is governed more by dynamical architecture than by the presence of a delivering giant, then characterizing the outer architecture of nearby M-dwarf systems — searching for the cold giants that would threaten inner chains — becomes a habitability measurement, not merely a census. This connects to the observational program already forming around TRAPPIST-1-type systems, where transit spectroscopy aims to test whether the inner planets retain atmospheres and water at all (Meadows et al., 2023; Gomez, 2024). The leverage framework adds a complementary target: the outer dynamical environment. A compact chain with a clean outer system is, by this argument, a better habitability bet than an otherwise identical chain shadowed by a distant giant.

I want to close the analysis by resisting a tempting overreach. It would be easy to convert the sign-inversion claim into a slogan — "giants are bad for red dwarfs" — and to forget the conditions that make it true. The claim holds for compact resonant chains that hydrate themselves by pebble drift; it need not hold for every conceivable M-dwarf terrestrial system. A red-dwarf system that formed its inner planets by a different route, or that lacks a resonant chain, might depend on outer perturbations for water in the way the Solar System did, and there the leverage could be positive again. The framework's value is precisely that it makes the answer depend on architecture rather than on a blanket rule, and I would betray that value by replacing one blanket rule ("giants help") with another ("giants harm"). What the framework says is narrower and, I think, more defensible: for the specific and common architecture that red dwarfs favour, the giant's leverage is negative, and their scarcity of giants is correspondingly benign.

CONCLUSION

This article asked whether the Sun-like intuition that an outer giant benefits inner habitability transfers to red dwarfs, and the answer the analysis supports is that it does not — that the giant's role inverts. The first hypothesis, that a giant's effect on inner terrestrial habitability is a genuine leverage rather than a fixed-sign influence, is supported: decomposed into water-delivery, dynamical-stability and impact channels, the giant's net effect is mildly positive for a Sun-like architecture and distinctly negative for a compact M-dwarf chain, a reversal that no single-signed description could capture. The second hypothesis, that around red dwarfs this leverage is predominantly negative, is likewise supported, and the results locate the reason: compact chains obtain their water endogenously through pebble drift and their stability through resonant locking, so an outer giant supplies little the system lacks while threatening the fragile architecture on which it depends. The third hypothesis, that the observed scarcity of giants around red dwarfs is consistent with, and may enable, the habitability of their terrestrial systems, follows from the first two and is the article's most consequential suggestion: the missing giants are not a deficiency but a protection.

The principal original contribution is the Giant-Planet Habitability Leverage framework and its signed index, which decomposes a giant's influence into three physically distinct channels and combines them into a single number whose sign states whether the giant helps or harms inner habitability, and which is applied comparatively across stellar mass to yield the specific, falsifiable claim that the leverage changes sign between solar-type and M-dwarf architectures. The contribution is not another qualitative discussion of whether Jupiter is a friend or a foe, but an instrument that forces the question to be answered architecture by architecture and that turns a folk heuristic into a testable, disputable statement. Where prior work treated water delivery, dynamical stability and impact rates separately and mostly for Sun-like systems, the framework binds them and asks how their balance shifts with stellar mass — and finds that it shifts enough to reverse the conclusion.

The limitations are substantial and I state them plainly. First and most serious is the single-author, heuristic scoring: I assigned every channel value myself from the literature, without independent raters or a unified simulation, so the composite numbers carry an unquantified subjectivity that only explicit dynamical modelling could discipline. Second, the water channel in particular is scored with low confidence, because the pebble and scattering pictures may blend and late-forming giants may obstruct little; I have argued that the net conclusion survives even if this channel is merely neutral, but a reader who rejects the negative water score should note that the argument then rests entirely on the dynamical channel. Third, the three archetypes are deliberately stylized, and real systems occupy a continuum; a distant, near-circular giant may fall in the narrow benign corner the analysis acknowledges. Fourth, the occurrence statistics needed to test the framework's central prediction are not yet precise enough at low stellar masses, so the strongest empirical confrontation lies in the future rather than the present.

Three directions for future work follow directly. The first is to replace the heuristic index with explicit N-body and secular integrations: injecting plausible cold giants into stability models of observed compact chains and measuring the change in survival time would turn the dynamical channel from an estimate into a calculation. The second is observational: as radial-velocity, astrometric and transit surveys tighten the census of outer companions to M-dwarf systems, the predicted anticorrelation between cold giants and intact inner chains becomes testable, and a clean test would either vindicate the framework or bound its scope. The third is to extend the leverage concept beyond giants to the full outer architecture, asking which configurations of any outer mass are protective and which are corrosive for a given inner chain. Whether the sign inversion proves as general as I suspect is an open question I cannot settle here; but if it holds, then the search for habitable worlds around red dwarfs should look not only at the inner planets and their star, but at the empty outer spaces where a threatening giant is, tellingly, absent.

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ULOGA JUPITEROLIKIH PLANETA U DINAMIČKOJ STABILNOSTI NASTANJIVIH ZONA KOD CRVENIH PATULJAKA: DOSTAVA VODE, ORBITALNA STABILNOST I PROMJENJIVI PREDZNAK POLUGE GASOVITIH DIVOVA

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Sažetak: Kod zvijezda sličnih Suncu udomaćila se udobna pretpostavka da je spoljašnji gasoviti div dobar za nastanjivost unutrašnjih terestričkih svjetova — pomaže dostavi vode i, u popularnoj slici, štiti unutrašnji sistem od bombardovanja. Ovaj rad tvrdi da ta pretpostavka ne važi za crvene patuljke i da je, za kompaktne rezonantne sisteme tipične za zvijezde male mase, spoljašnji div češće teret nego prednost. Razvijam okvir poluge nastanjivosti gasovitih divova, koji razlaže neto uticaj diva na dugoročnu nastanjivost unutrašnje terestričke planete na tri kanala — dostava vode i isparljivih materija, dinamička stabilizacija naspram pobude, i modulacija sudara odnosno čišćenja — i objedinjuje ih u jedan predznakovni indeks (GHLI) koji može biti pozitivan (div pomaže) ili negativan (div šteti). Primjenom okvira na tri arhetipa — sistem nalik Suncu sa Jupiterom, hipotetički kompaktni lanac oko crvenog patuljka sa nametnutim hladnim divom, i lanac bez diva tipa TRAPPIST-1 — nalazim da poluga mijenja predznak sa masom zvijezde: blago pozitivna do neutralna za solarni slučaj (GHLI ≈ +0,3), ali izrazito negativna kada se hladni div doda tijesno pakovanom lancu oko patuljka (GHLI ≈ −0,5). Mehanizam je u tome što kompaktni sistemi oko patuljaka vodu dobijaju endogeno, kroz drift šljunka preko linije leda tokom formiranja, a stabilnost iz rezonantnog zaključavanja, pa spoljašnji div daje malo onoga što sistemu nedostaje a prijeti krhkoj rezonantnoj arhitekturi. Zaključak je da uočena rijetkost gasovitih divova oko crvenih patuljaka, umjesto da bude prepreka nastanjivosti, vjerovatno predstavlja jedan od njenih omogućavajućih uslova.

Ključne riječi: *egzoplanete, crveni patuljci, TRAPPIST-1, gasoviti divovi, nastanjiva zona, dinamička stabilnost, dostava vode, nebeska mehanika.*