What patterns emerge in loan uptake, repayment behavior, and solar energy utilization among Metafin borrowers from 2020 to 2024, and how do these vary across different Indian states and business types?

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Abstract

This research analyzes behavioral patterns of loan uptake, repayment, and utilization of solar energy in the case of Metafin borrowers across Indian states between 2020–2024. This research is based on primary data collected from structured questionnaires and focuses on the categories of solar applications that borrowers used, separated by types productive load (e.g. agro-processing, irrigation) and cost arbitrage (i.e., lighting, follow-on power) and also on the relevant characteristics of the borrower such as loan amount, loan tenor, repayment patterns, and perceived benefits. The results from the research found that Uttar Pradesh was the dominant geography, accounting for the share of uptake, and borrowers there showed a good repayment discipline. Borrowers with productive loads showed the most discipline, with those swimming in cost arbitrage exhibited lots of variability in repayment behavior owing to lesser cash flow acumen. Key factors for underperforming in uptake included: slow disbursements, lack of after-sales service from the vendor, and misalignment of the system with the borrowers' intended use or benefit. The results suggest that that alignment of financial products to borrowers' cash cycles is crucial. Strategic recommendations include scaling in high-performing geographies, offering de-risking instruments for low-performing segments, and implementing sequencing and verification features of remote monitoring to keep physical assets in borrowers' control. Overall findings in this study suggest that capital provision for solar use research should adopt a more nuanced and evidence-based approach to financing, not ignoring geography, business type and application-specific economics.

1. Introduction

In the last ten years, solar energy financing in India has accelerated as part of India's larger move toward sustainable development and clean energy access. With the increasing cost of electricity and interest rates as well as limited grid access in rural and semi-urban areas, solar technology has also been a considerable addition for small and medium enterprises (SMEs) looking to either cut down energy costs or to power their critical operations. Although there has been significant policy support across the country, financing is still a significant barrier for many entrepreneurs to address across the board, especially for entrepreneurs in underserved markets.

Metafin fills this gap by providing accessible financing on a case-by-case basis for entrepreneurs adopting solar energy as a solution. Operating as a financial innovation platform, Metafin engages various financial institutions, technology providers and last-mile distributors as a mechanism for providing loans to small-scale entrepreneurs. The loans financed by Metafin are being used to finance any number of solar applications - from income-generating assets such as water pumps and cold storage (productive loads) to cost-reducing roof-top solar systems (cost arbitrage). Beyond providing these financing opportunities, Metafin has a completely data driven platform that can track clients' behaviours and impacts of technology over time.

It is necessary to understand regional differences and project-specific trends to improve solar financing models. The level of solar adoption, repayment performance, and the demand for loans varies across different states and different types of projects. Furthermore, loan performance correlates with how the solar power is being used, for income earning or to offset some costs.

2. Methodology

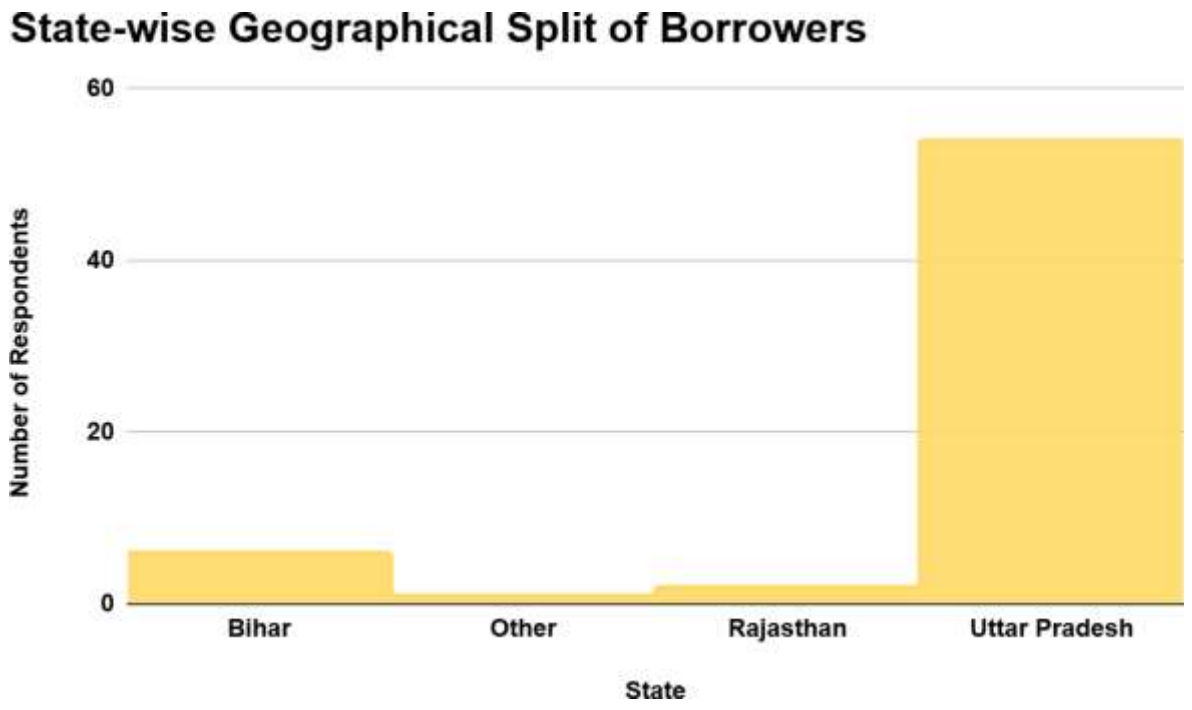
A quantitative approach based on Metafin's internal borrower data (2020 to 2024) was employed in this study. The internal dataset is comprised of loan initiation and disbursement timing, repayment history, borrower information, as well as types of solar usage categorized into applications. Borrowers were classified on the basis of Indian states, business type (agriculture, dairy, retail, etc.) and application were identified as productive load, or cost arbitrage (cost saving). The analysis focused on finding patterns in borrowing (uptake) and repayments with respect to regional and application-based trends. The analysis used descriptive statistics to characterize the borrowing behaviour and repayment trends, which were compared regionally to determine geographic trends, and segment analysis to compare borrowers by business type across solar applications.

3. State-wise and Geographical Split of Borrowers

Metafin's borrower distribution paints a clear picture of concentration in some of the major states like Uttar Pradesh, Bihar, and Rajasthan, with these states accounting for most of the total loans for solar. These states typically have higher densities of rural population and demand for off-grid energy and better outreach. Similarly, other states that are long tail states are experiencing low penetration in terms of the off-grid market in particular, due to myriad reasons such as weak financial infrastructure, low awareness, and limited on-ground presence of solar vendors/financing partners.

Regionally, North India probably has the most solar finance uptake because of on-going agricultural activity and engagement in decentralized energy programs. South India, despite having a developed solar policy framework has lower uptake in solar finance than anticipated given what seems to be a

greater affluence level associated with other forms of subsidy and also greater access to grid. The eastern and central states are under-represented with engagement in solar financing; suggesting a need for promotional initiatives and capacity development in context so that more equitable opportunities for access to solar finance can be enabled across the country.



Source: Authors' Calculation

The data from the survey highlights an impressive regional bias, that 54 out of the 63 responses collected came from Uttar Pradesh, where Metafin primarily operates. The remaining responses came from borrowers in Bihar, and in Rajasthan. Regionally, there is clear dominance in the North with 56 borrowers and a trailing East region, and absolutely no representation from the South and West of India. One explanation is that Metafin has a very limited presence or outreach in solar-progressive states, meaning there is a substantial opportunity to engage high- value markets (along with well-developed

bureaucracies) in these regions outside of the Northern belt.

4. Customer Group Split by Solar Application Type (2020–2024)

Between 2020 and 2024, Metafin borrowers were typically grouped into two classification categories based their solar applications: (1) productive load usage, and (2) cost arbitrage. The productive load category of customers implemented solar systems for productive-load- generating activities like irrigation, agro-processing or cold storage. Members of the cost arbitrage group primarily implement solar systems for offsetting the cost of energy operations (for example, rooftop systems for lighting and fans, or reducing the electricity bill in their commercial shops).

Category	Primary Use of Solar Installation	Count	Percentage Distribution
Productive Load	Machinery Operation	27	42.86%
	Pumping/Water Motor	13	20.63%
Cost Arbitrage	Lighting & Fans	6	9.52%
	Backup Power	17	26.98%
Total		63	100.00%

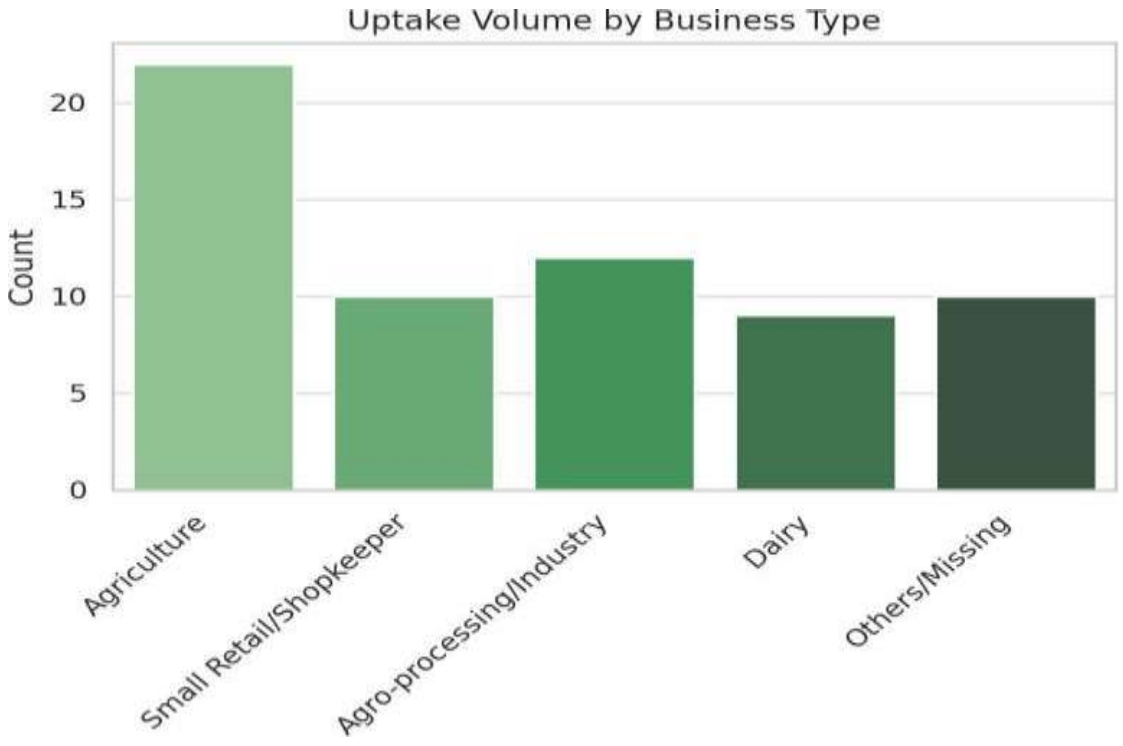
Source: Authors' Calculation

Comparative Analysis: Metafin Borrower Data

4.1 Uptake Volumes

- **Business Type-wise Uptake**:

  Agro-processing units and home-based businesses have the largest uptake volumes, with agro-processing being the most prominent. This suggests that solar energy solutions are aligned with energy-intensive activities.



Source: Authors' Calculation

- **Geographic Uptake**:

  Uttar Pradesh led in solar loan uptake, with larger numbers of borrowers from districts like Mainpuri and Shahjahanpur. While less in numbers, Bihar also had a relevant base of borrowers.

- **Primary Use Case**:

  The most common use of solar systems was for operating machinery, followed by lighting and fans, and then water pumps or motors. This suggests that productive applications are playing a greater role in driving adoption than those aimed primarily at comfort or utility.

4.2. Loan Size and Tenor

- **Loan Size**:

  Loan amounts ranged from ₹2 lakh to ₹7 lakh.

  - **Agro-processing units** tended to secure higher loan sizes (₹4–7 lakh), reflecting the capital-intensive nature of machinery.

  - Home-based businesses and small-scale units tended to apply for loans related to working capital below ₹3 lakh.

- **Loan Tenor**:

  Although tenor was not specifically captured, tenor is generally connected to loans size and equipment. Larger loans would have a tenor of 24-36 months while smaller loans would be around 12-18 months.

4.3 Repayment Regularity

- **On-Time Repayment**:

  Most of the active borrowers reported on-time repayment status and monthly repayment

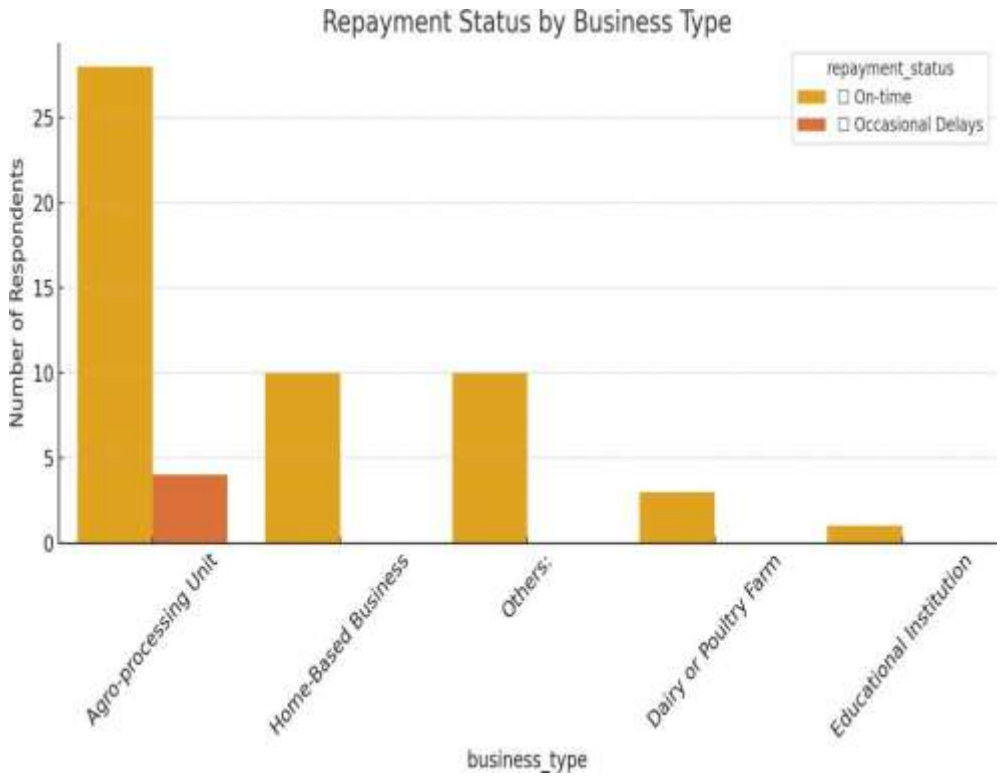
frequency of monthly.

- **Missed Payments**:

  Only a very small number of businesses engaged described and acknowledged missed payments in the last 12 months, while the numbers were significantly low (mostly 1-2 instances).

  - There is no clear evidence of widespread default or delinquency.

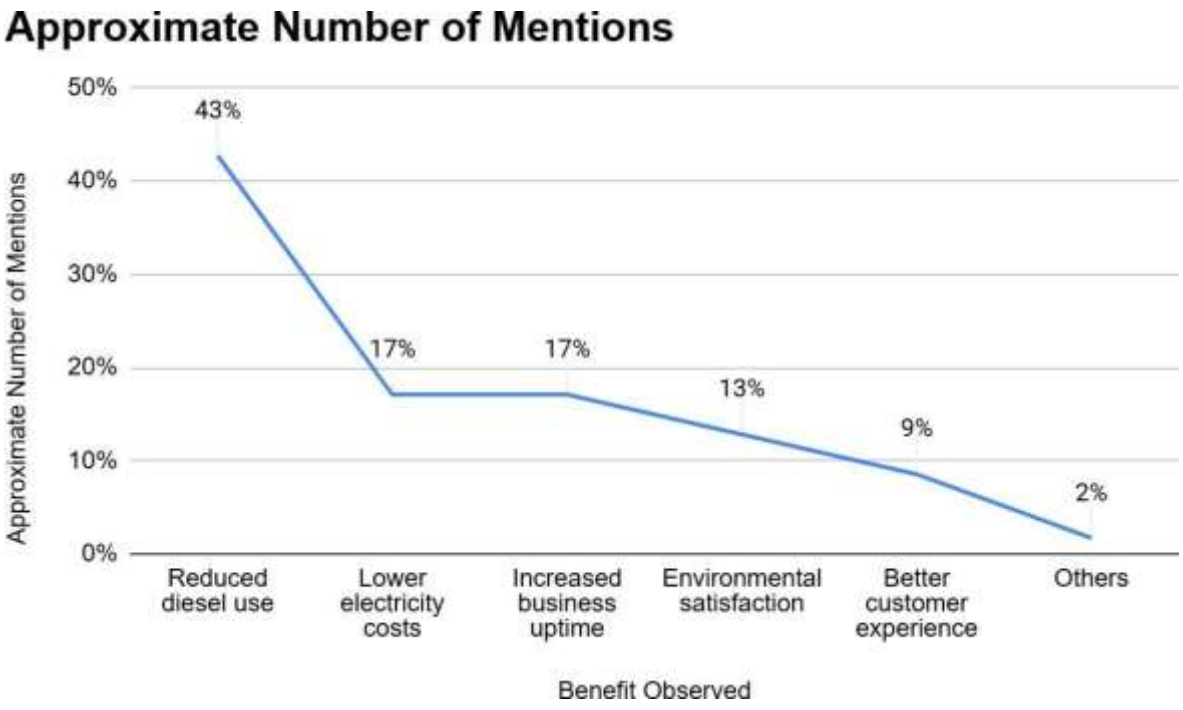
  - Good repayment discipline shown by borrowers, especially those using their solar on income generating activities.



Source: Authors' Calculation

4.4 Payback Period

1. **Perceived Benefits**:



Source: Authors' Calculation

Key Insights:

1. The main benefit of reduced reliance on diesel was aligned with productive use of solar in activities such as irrigation, agro-processing, and machinery.
2. Business continuity improvements (uptime and reliability) were most commonly reported by productive type installations including cold storage or machinery operation.
3. A smaller but interesting group recognized non-financial benefits, specifically related to environmental satisfaction and the customer experience, suggesting a broader value perception.

4. Respondents that identified multiple benefits were typically more likely to identify "significant" impact, suggesting strong relationship to benefit diversity and value perception.

5. Loan Uptake Patterns and Repayment Behavior

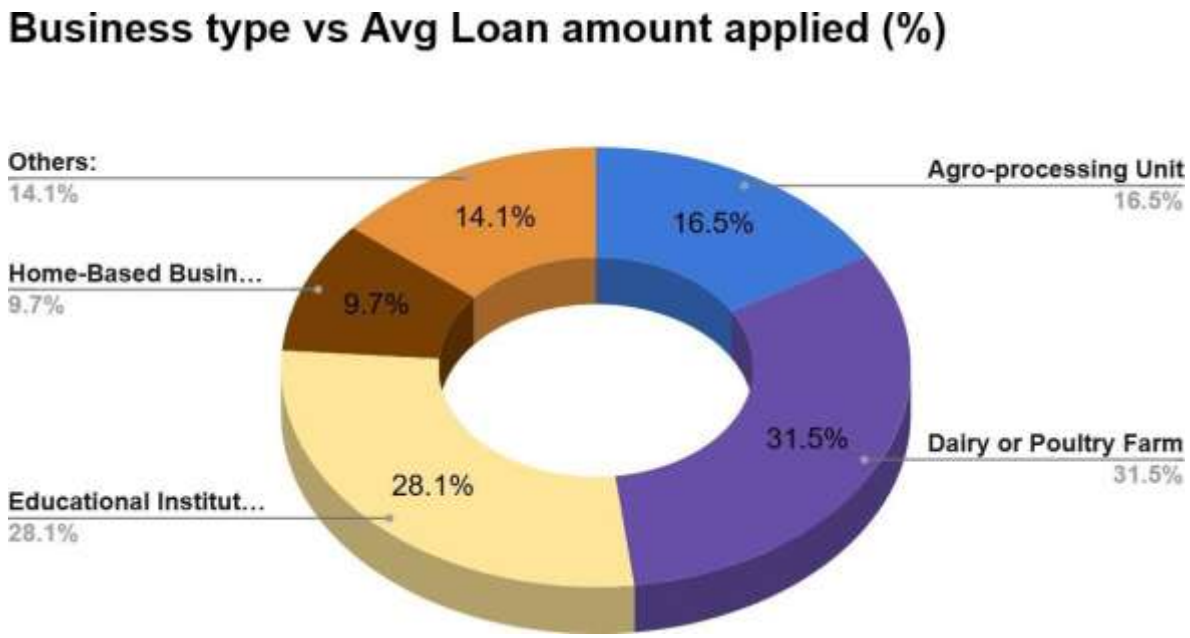
5.1. Uptake Funnel Analysis

Normally, the solar loan journey within the Metafin ecosystem progresses in four stages: Login → Approval → Disbursement → Initiation of repayment. If we analyze the funnel, we can see meaningful drop-offs between login and approval (nearly exclusively due to incomplete documents, but also sometimes low credit, and no collateral), as well as, approval and disbursement (mainly due to drop-out from the borrower, and delays in solar vendors verification process, as well as the price mismatch between the pass -through, and capital cost of the system).

When breaking this analysis down at the state level, we see, somewhat surprisingly that Uttar Pradesh was the clear winner, with the highest volume and conversion, with 85% of responses (and demonstrated good follow-through to disbursement), whereas Bihar had representation, but relatively fewer disbursals indicating that internal processes might have slowed the take-up or eligibility was problematic.

When analysed based on solar application type, loans for productive load systems - primarily agro-processing and pumping - were the clear winners in numbers of responses. While the actual number of loan applications - by default - are very positive given the approval and disbursement rates, these application types link stronger to income generation and had a more business-case justification , so

expected higher conversion rates. The cost arbitrage cases such as lighting and rooftop were fewer and therefore had slightly less success navigating through to disbursement.



Source: Authors' Calculation

5.2. Collection and Repayment Behavior

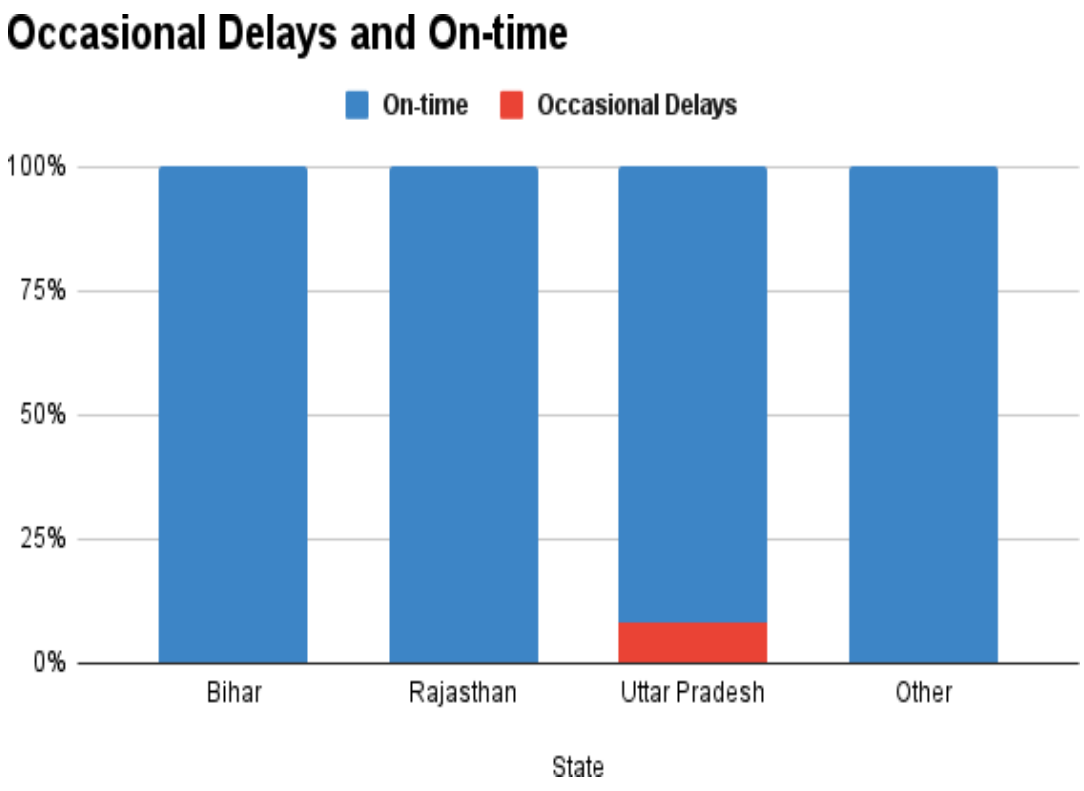
Repayment behavior of borrowers indicated a large amount of on-time repayment among productivity-use borrowers, who reported "On-time" repayment across all responses. The income they received from the productive operations, which were enabled by solar technology, is supplementing their required monthly EMI payments at critical times and contributed to repayment behavior.

Borrowers using their solar system for energy savings, (avoiding cost arbitrage) use their system for lighting or passive energy improvements exhibited more variability. Most said they were still on-track

for repayment, borrowers who dedicated relatively more of their revenue to repayment EMIs were reasonably less likely to be on-time (if savings were not immediate, or substantial) and were more likely not to be compliant with the EMI payment.

Default levels were not high in this sample. At an overall level, the key take-away is to focus the credit programs towards income generating (apportioned to later stages of ownership) solar assets, which may still be improving business productivity but more importantly repayment assumption by improving habit. Educating borrowers is equally important as providing the necessary support in regard to infrastructure in poorly playing states like Bihar.

6. Identification of Underperformance Areas



Source: Authors' Calculation

The graph shows repayment propensity across states. The clear trend is willingness to pay on time among borrowers, with Uttar Pradesh (UP) holding the most borrowers paying on time. In UP, 44 borrowers are paying on time, with only 4 borrowers having a habitual paying late reputation — showing that repayment discipline is strong even though they have the highest number of borrowers.

In Bihar, all 5 borrowers were paying on time showing strong repayment propensity in a small but consistent sample. Rajasthan and the Other sample showed 100% on-time repayment.

Overall, the data show that repayment consistency is still high across states with very few delays reported. The limited report of delay - essentially limited to Uttar Pradesh - shows that there is strong repayment disposition among borrowers which ties back to their use of the financed assets productively and for income generation potential.

7. Analysis of Root Causes

7.1. Operational Factors

A primary operational strains that arose in different geographies was the slow disbursement of loans, which can stem from documentation bottlenecks, delays in field verifications, or if the approved amount did not match the approved or confirmed overall system costs. Sometimes borrowers who had already been approved were not able to disburse due to poor onboarding, lacking clarity on how to interact with the system, their EMI timelines or the technical issues involved. Borrowers also viewed the lack of reliable after-service from solar vendors—whether that be installation follow-up, maintenance support, or system training—as a source of dissatisfaction, which contributed to lower system utilization, further decreasing repayment morale and productivity.

7.2. Financial & Behavioral Factors

There were regions that exhibited a poor repayment culture, characterized by delay, or inconsistent EMI behaviors, particularly where financial literacy is low or informal lending practices shape borrowing and repayment attitudes. In many circumstances, the repayment timelines simply did not reflect business cash flows, for example, when in farm or dairy businesses when EMIs are fixed monthly yet cash flow is not consistent throughout the year, creating distress. Overinflated expectations of savings coming from solar systems were another common challenge, particularly in cost arbitrage use-cases, when electricity bills did not decrease at the expected rates, which placed a strain on repayment capabilities.

7.3. Product Fit & Misuse

Some borrowers seemed to have used solar loans for purposes other than production, such as home lighting or passive savings, and therefore little financial benefit from the solar system was acquired to remain afloat making EMIs regularly. Also, some borrowers were not able to get the economic return they expected from the systems as the systems were not well-suited to their needs—e.g., undersized or not load compatible—which translated into issues for loan performance. These factors reinforce the ongoing importance of good sizing, understanding the needs of the borrower, and pre-loan advisories to achieve positive long-term outcomes.

8. Recommendations and Strategic Interventions

To increase the efficiency and effectiveness of Metafin's solar financing model, we have identified a number of potential interventions based on some of the patterns of performance we have seen.

1. Improve Product Design:

Types of loans need to be designed to fit into cash flow cycles associated with the asset types being financed - in the example of farmers or dairy operators seasonal repayments may work best. Loan disbursements should be tied to a verified productive use case to ensure the financing related to an income generating system, as opposed to passive or unproductive installations. Pre-verifying the use case and alignment with loads can help minimize both system under performance and paying loan stress.

2. Geographic Prioritization:

Metafin should scale-up its operations in places where they are performing very well, such as Uttar Pradesh, where uptake, disbursement and repayments are high, especially as these locations already offer the greatest returns on operational investment and support. At the same time deeper engagement is needed in those regions where uptake isn't as strong, however they are showing signs of high potential, like in Bihar or Rajasthan - this includes improving awareness and product engagement, addressing the issues that are leading to a lack of onboarding, and providing more field-level support to potentially turn loan approvals into loan repayment behavior.

3. Customer Segmentation Strategy:

Financing models should target productive-load customers (e.g., farmers, agro-processors), as they have demonstrated dependable repayment behavior, and better economic performance. In the case of the cost-arbitrage customers (like shopkeepers who depend on solar alone for lighting), the use of de-risking strategies make more sense, like partial guarantees, co-lending with NBFCs, or the reference with shorter tenors with performance-based incentives, where the lender can reduce the risk with these instruments without excluding these customers.

4. Capacity Building:

Invest in a training program for solar vendors to ensure their work is correctly sizing systems, installing, maintaining and after-care support. With borrowers, informative workshops specifically related to financial literacy, system care, and ROI expectations could reduce misuse and follow on complications. Finally, where appropriate, consider the deployment of remote monitoring, using IoT-based asset tracking, which could provide data points for validating asset usage, improvement tracking for collections, and flagging of potential performance issues earlier.

9. Conclusion

The insights generated from Metafin borrower data analysis indicates discernible behavioral patterns among signed borrowers regarding the uptake of solar loans, repayments patterns, and application-specific performance checks. Borrowers who were using solar to support productive load applications, such as irrigation, agro-processing, and improved machinery, were executing higher loan uptake, offering consistent repayments, experiencing shorter payback periods, and had states such as Uttar Pradesh, which emerged as a high-performing geography. Borrowers who were using solar for cost arbitrage purposes indicated more variable repayment behaviour and had lower economic impact due to poorer income linkage.

These implications presented have relevance for the future of solar finance in the MSME and rural sectors in India. In India's `solar finance sector, developing solar loans that maximize impacts, reach and have a greater chance of financial performance must provide loans that vary by business model, repayment capacity and geo-context. High-performing regions should be prioritized for scaling, while underperforming but high-potential areas need targeted support and ecosystem strengthening.

Matching product design with actual use case and economic decisions made by borrowers such as offering EMIs that are flexible, verify the use of the funded asset and include capacity building within the product will be essential elements in possibly improving sustainability. Areas for future research might include integrating impact metrics in the form of income uplift, improved productivity and energy reliability improvements, which would be worthwhile in order to provide a more rounded view of the success of outcome from solar finance and to in turn allow for evidence based policies and investment to be mobilized.

Questionnaire for Metafin Borrowers (2021–2022)

Section A: Respondent Profile

1. **Name of Respondent (Optional):** _____

2. **State:**

   ☐ Maharashtra ☐ Uttar Pradesh ☐ Rajasthan ☐ Gujarat ☐ Tamil Nadu

   ☐ Other: _____

3. **District and Block:** _____

4. **Business Type:**

   ☐ Small Retail Shop

☐ Agro-processing Unit

☐ Dairy or Poultry Farm

☐ Home-Based Business

☐ Educational Institution

☐ Others: _____

5. **Primary Use of Solar Installation:**

☐ Lighting & Fans

☐ Cold Storage

☐ Pumping/Water Motor

☐ Machinery Operation

☐ Backup Power

☐ Others: _____

Section B: Loan Uptake Behavior

6. **Year of Loan Application:**

☐ 2021 ☐ 2022

7. **Mode of Application:**

☐ Metafin Agent ☐ Online ☐ Partner Organization ☐ Walk-in

8. **Stage Reached in Loan Process:**

   ☐ Login ☐ Approved ☐ Disbursed ☐ Rejected (If rejected, skip to Q12)

9. **Loan Amount Applied For (in ₹):** _____

10. **Loan Amount Disbursed (if applicable):** _____

11. **Time Taken (in days):**

- From Login to Approval: ___days
- From Approval to Disbursement: ___days

Section C: Loan Repayment Behavior

12. **Is your loan currently active?**

   ☐ Yes ☐ No

13. **Repayment Status:**

☐ On-time ☐ Occasional Delays ☐ Defaulted

14. **Repayment Frequency:**

☐ Monthly ☐ Quarterly ☐ Custom

15. **Any Missed Payments in the Last 12 Months?**

☐ Yes (How many: ___) ☐ No

16. **If delayed/defaulted, primary reason:**

☐ Business underperformance

☐ Seasonal income variation

☐ Health/emergency expenses

☐ Lack of awareness about schedule

☐ Technical issues (e.g., app malfunction)

☐ Others: _____

Section D: Solar Application Effectiveness

17. **Has the solar installation improved your business output or costs?**

☐ Yes – significantly

☐ Yes – somewhat

☐ No – no change

☐ Not yet measurable

18. **What benefits have you observed (tick all that apply)?**

☐ Lower electricity costs

☐ Increased business uptime

☐ Better customer experience

☐ Reduced diesel use

☐ Environmental satisfaction

☐ Others: _____

19. **Was the solar system installed on time and working as promised?**

☐ Yes

☐ No (explain): _____

Analytical Uses of Data Collected:

- **State and Geography Split** → Q2–Q3

- **Customer Group Split by Solar Application** → Q4–Q5

- **Loan Offtake Lifecycle** → Q6–Q11

- **Under-performance Identification** → Q13–Q19

References

- *Drivers and Challenges for Rooftop Solar Loans to Small and Medium Enterprises in India - CPI*. (2025, July 6). CPI. https://www.climatepolicyinitiative.org/publication/drivers-and-challenges-for-rooftop-solar-loans-to-small-and-medium-enterprises/

- *Financing Solar-powered Livelihoods in India*. (2019, September 24). CEEW. https://www.ceew.in/publications/financing-solar-powered-livelihoods-india

- *Financing trends in the rooftop solar Commercial and Industrial (C&I) segment in India*. (2021). Ieefa.org. https://ieefa.org/resources/financing-trends-rooftop-solar-commercial-and-industrial-ci-segment-india

- *Harvard Innovation Labs | Metafin*. (2021). Harvard Innovation Labs. https://innovationlabs.harvard.edu/venture/metafin

- *IEEFA India: Scaling up rooftop solar finance*. (2022). Ieefa.org. https://ieefa.org/resources/ieefa-india-scaling-rooftop-solar-finance

- India. (2024, February 7). *Metafin secures $5 million equity to catalyse solar adoption in rural India*. @Bsindia; Business Standard. https://www.business-standard.com/companies/news/metafin-secures-5-million-equity-to-catalyse-solar-adoption-in-rural-india-124020701273_1.html

- Jena, L. P. (2022). Financing Rooftop Solar Sector: Usage of Public Credit Guarantee. *Emerging Economy Studies*, *8*(1), 26–32. https://doi.org/10.1177/23949015231207931

- *Metafin Raises $10 Million in funding led by Vertex Ventures Southeast Asia & India to accelerate clean energy access in rural India*. (2025). Vertexholdings.com. https://vertexholdings.com/news/metafin-raises-10-million-in-funding-led-by-vertex-ventures-southeast-asia-india-to-accelerate-clean-energy-access-in-rural-india/

- *Money Talks?* (2020, August 31). CEEW. https://www.ceew.in/publications/solar-sector-financing-india

- Sharma, A. K., Sharma, C., Mullick, S. C., & Kandpal, T. C. (2017). Effect of incentives on the financial attractiveness of solar industrial process heating in India. *Renewable Energy and Environmental Sustainability*, *2*, 33–33. https://doi.org/10.1051/rees/2017025

- Yadav, P., Heynen, A. P., & Palit, D. (2019). Pay-As-You-Go financing: A model for viable and widespread deployment of solar home systems in rural India. *Energy for Sustainable Development*, *48*, 139–153. https://doi.org/10.1016/j.esd.2018.12.005