Knowledge Benefits: Assessing RD&D Program Impacts with Network Effects

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Research, development and demonstration (RD&D) is a critical ingredient for the advancement of energy technologies. Whether efficiency or renewables, problems that emerge as distributed resources enter the energy market need solving, and investing in fundamental solutions through RD&D makes a unique contribution. Assessing the value of investment in RD&D, however, is difficult. It takes time for effects such as new products, changes to the grid, jobs, and other economic and energy benefits to surface. Therefore, RD&D program evaluation frequently looks for increases in knowledge by tabulating discrete indicators like the number of patents generated, articles published, or citation by other researchers. It is not uncommon for the benefits of RD&D programs to become visible 20-25 years after the program.

This poster presents our network-based approach for exploring knowledge network effects. We assessed the usefulness of outputs from a state funded R&D program to researchers and practitioners in the same field, or facing the identified challenge, but who did not receive funding. Starting with a logic model to identify the short, medium and long-term outcomes expected to emerge from the RD&D program, we developed subsets of early knowledge indicators. These indicators included short-term indicators like network composition, awareness of program outputs, and follow-on work commitments; medium knowledge effects such as scholarly papers and patent filings, and long-term knowledge effects such as reduced duplication and closing of knowledge gaps.

We developed a body of data through a combination of content analysis, interviews and survey data. The data were used to assess the degree to which the RD&D program projects were influencing solar researchers. The data were shaped to represent a network analysis dataset, with attributes representing project knowledge, modes of knowledge transfer, and knowledge recipients integrated into the head and tail of network edges. Using the network analysis data, we created network diagrams that depict "immediate", "intermediate", and "distant" degrees from the program, illustrating both the variation of knowledge transfer at each level and the knowledge-recipient fit of knowledge exchange. The insights gleaned from assessing knowledge pathways using network analysis were complemented with a rigorous research question framework developed using key principles of knowledge diffusion theory (e.g., absorptive capacity, tacit knowledge exchange, learning-by-doing).

KNOWLEDGE BENEFITS:
Assessing RD&D Program Impacts with Network Effects

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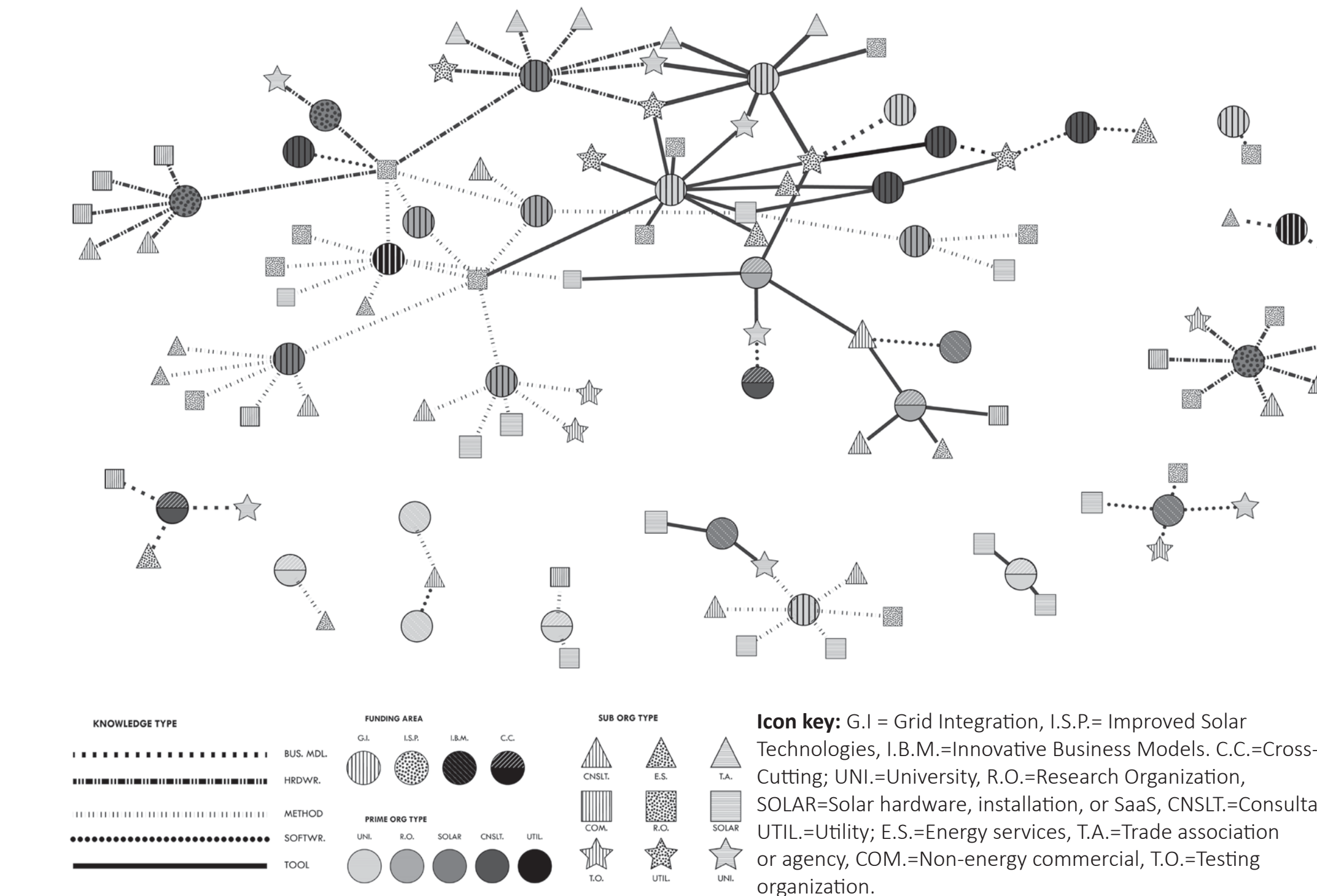
THE CHALLENGE:

When implemented correctly, RD&D programs address technology and knowledge gaps, but assessing the economic, social, and environmental value of RD&D program investments is hard, especially in the short-term.

- Measurable workforce and economic output data emerge slowly, accumulating over time

- Among the key outputs of RD&D programs, knowledge can be packaged and transferred, but know-how is less transferable

- Program designs are highly individualized

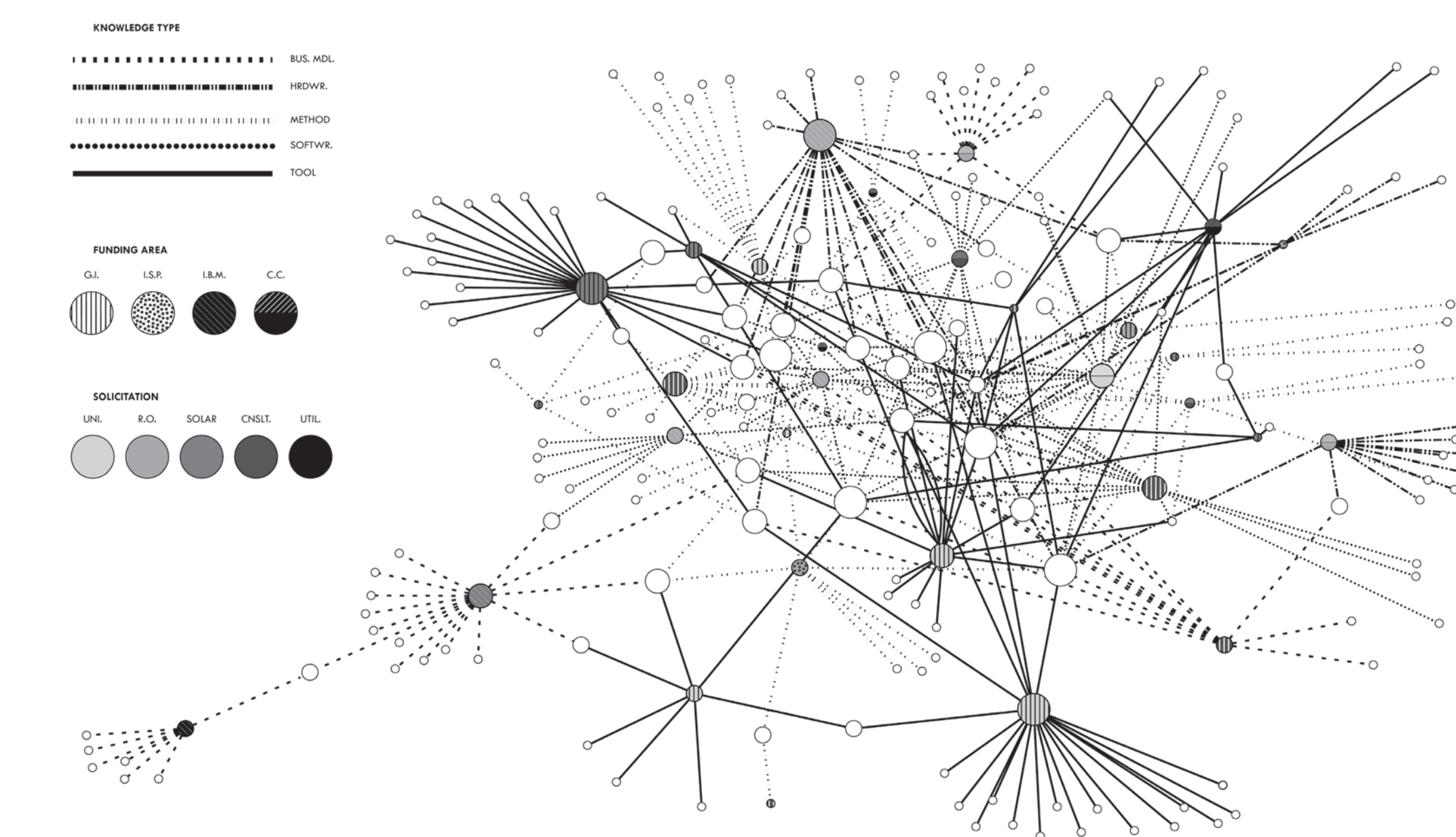## IDENTIFIED EARLY INDICATORS BY INVESTIGATING KNOWLEDGE BENEFITS

- We explored the knowledge benefits, looking for network effects that are observable earlier than economics effects.

ASSESSED HOW KNOWLEDGE BENEFITS ACCRUED TO THE STATE, THE SOLAR COMMUNITY, AND THE ENERGY INDUSTRY; INCLUDING:

- Trajectory of knowledge diffusion based on the fit of knowledge produced relative to the intended audience;

- The means by which knowledge is transferred to market actors; and

- Existing knowledge capacity that the Program drew on, and the extent to which the Program built additional knowledge capacity.

Impact Factors	Indicators	DATA SOURCES				ANALYSIS APPROACH		
		Interview	Program Content	Survey	Citation Review	Network	Qualitative	Survey
Relationship Building	Team composition	✔	✔			♦	♦	
	Team working dynamics	✔				♦	♦	
	Project partnerships	✔	✔			♦		
Knowledge Dissemination	Knowledge exchange activities	✔	✔			♦	♦	
	Efficacy and fit of exchange activities	✔		✔		♦		
	Knowledge spillover & external interest	✔	✔			♦		
	Influential knowledge disseminators	✔	✔			♦		
Knowledge Gaps Filled, Follow on Production	Knowledge gaps & application	✔	✔	✔		♦	♦	
	Target audience & knowledge recipients	✔	✔			♦		
	Intellectual property & intention to use	✔		✔		♦	♦	
Citation Analysis					✔	♦		
Market Actor Awareness & Perceptions				✔		♦		♦

KEY FINDINGS	
Team composition set the stage for strong knowledge capacity benefits	• Positioned for long-term knowledge benefits across the Program
	• Teams leveraged rare skills, strong market position, and operational know-how
	• Included a mix of private sector firms and public research organizations
Team dynamics improved efficiency, knowledge transfer, and follow-on production	• Highly collaborative, led to high degree of follow-on collaboration
	• Partnerships formed among team organizations, between team organizations and stakeholders, and between team members and market actors
	• Evidence that significant knowledge and absorptive capacity built
Follow-on application of Program knowledge is under way	• Includes RD&D projects, client services, expansion of products and services, direct use by outside partners
Teams highly committed to knowledge transfer	• Teams went well beyond Program-required knowledge exchange activities
	• High degree of opportunities for knowledge spillover, due to number of resources freely to the public
Making the right connections proved difficult	• Program-required webinars and reports was viewed to be ineffective knowledge transfer methods
	• Teams sought out one-off and non-required knowledge exchange activities to reach target audiences
The Program reached a broad audience, but not always the intended audiences	• Program administrators effectively facilitated creation of stakeholder and market actor relationships with teams
	• Program required knowledge exchange activities resulted in overly concentrated audiences
California market actors exhibit high degree of familiarity with Program, projects	• Market actors engaged in R&D, and grid operation and management; and, electricity market services most valued Program outputs
	• Market actors are currently using Program outputs to educate their clients, to inform R&D, and to improve products and services
	• Broad agreement that benefits are accruing to the California market and ratepayers

NETWORK COMPOSITION OF PRROGRAM TERMS

Icon key: G.I = Grid Integration, I.S.P.= Improved Solar Technologies, I.B.M.=Innovative Business Models. C.C.=Cross-Cutting; UNI.=University, R.O.=Research Organization, SOLAR=Solar hardware, installation, or SaaS, CNSLT.=Consultant; UTIL.=Utility; E.S.=Energy services, T.A.=Trade association or agency, COM.=Non-energy commercial, T.O.=Testing organization.

Overview: Network of organizations engaged during Program implementation
Key takeaway: Network context led to creation of social capital within the Program, and is well-positioned to facilitate knowledge diffusion and knowledge spillovers
Key points:
• Teams clustered by funding area and knowledge type
• Teams in a few funding areas somewhat isolated from the rest of the network
• High degree of reciprocity and transitivity

KNOWLEDGE RECIPIENT NETWORK

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Overview: Network of direct knowledge recipients engaged during Program implementation
Key takeaway: The network estimate in this diagram indicates that the Program succeeded in creating a dense, valuable network
Key points:
• Significant interaction and overlap between knowledge recipients and teams
• Remarkably dense network, implying high propensity to create social capital and transfer knowledge
• Network density is likely result of deliberate efforts by the Program to connect teams with key actors in the California market

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