SWEDEN'S TRANSITION TO A FOREST-BASED BIOECONOMY

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Background

> ... how radical changes can occur in the way societal functions are fulfilled. (Köhler et al., 2019, p. 2)

Socio-technical systems (Geels, 2004; Geels & Schot, 2007), innovation systems (Bergek et al., 2015; Hekkert et al., 2007)

Data From SWINNO Database

~ 5000 significant Swedish innovation

LBIO method

from 15 independent trade journals (Sjöö et al., 2014)

Example Page From a Source Article

Quantifying Directionality and Innovation Output

RQ

1. How many innovations are commercialized in this new economy, especially considering the central role of innovation in bioeconomy discourse?

2. What does commercialized innovation suggest for the positive directionality of the bioeconomy transition?

Data – Defining the Bioeconomy

Table 1: Key Sectors Used in Query

SNI Code	Description
02	Forestry and related services
20	Wood and wood product manufacturing except furniture
21	Pulp, paper and paper product manufacturing
36	Furniture manufacturing; other manufacturing

Table 2: Swedish Keywords used in Query: `WHERE description LIKE %keyword% OR ...`

Swedish	English
virke	timber
cellulos	cellulose
lignin	lignin
spån	chip
bark	bark
levulinsyra	levulinic acid
furfural	furfural
svarttjära	black tar
svartlut	black liquor
växtbas	plant-based
ved	wood
trä	timber
skog	forest
biobränsle	biofuel
biologiskt	biological
nedbrytbar	biodegradable
papper	paper
karton	carton
lyocell	lyocell

Bioeconomy Innovation Has Declined After 1970s

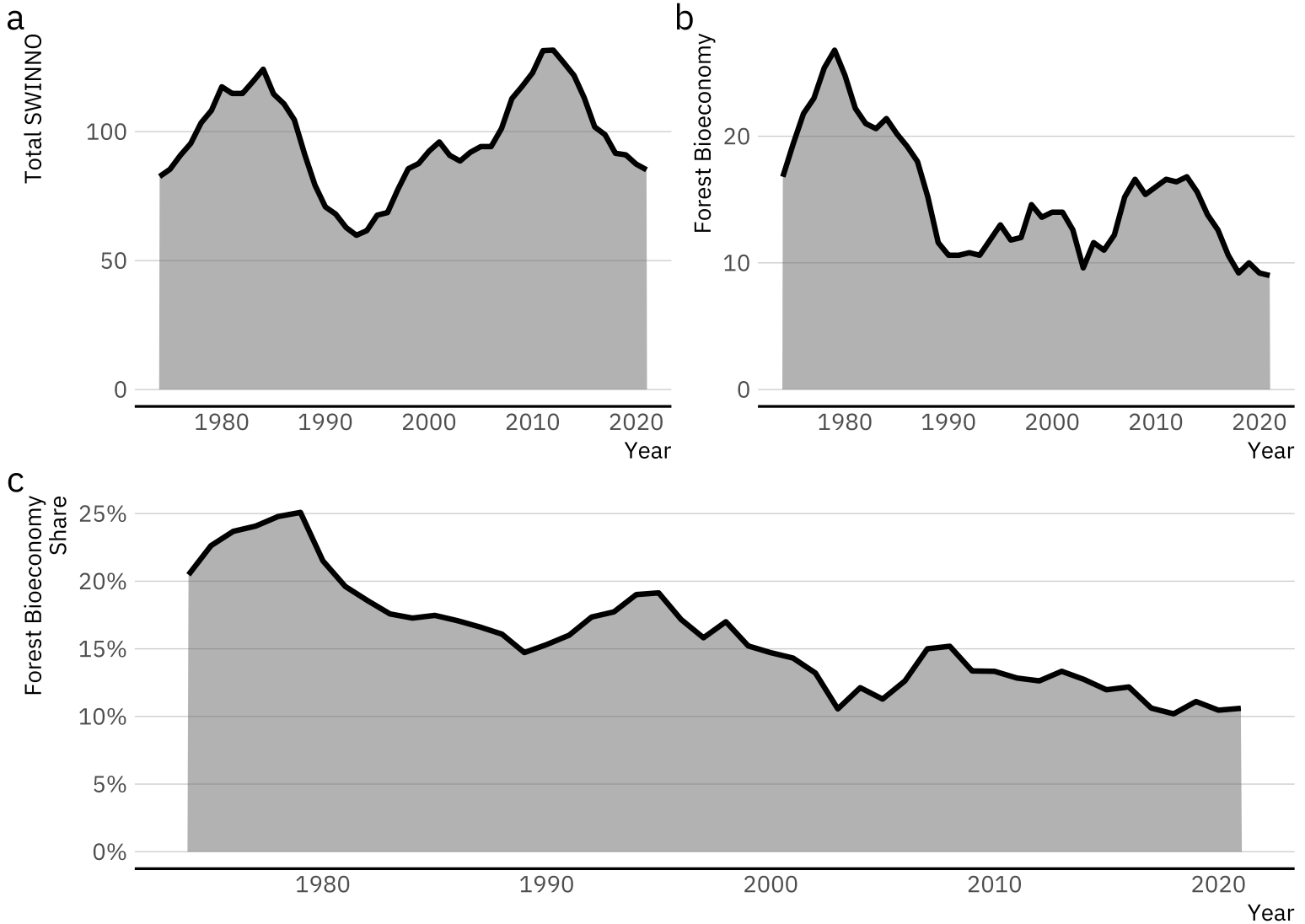

Figure 1: a. A total number of innovation registered in SWINNO database. b. Forest-based bioeconomy innovations registered in SWINNO database. c. Percentage of forest based bioeconomy innovations to total innovation registered in SWINNO database. Shown are the 5 year moving averages for each time series.

Three Visions for Normative Directionality

Bioresource

Biotechnology

Bioecology

Classification based on Bugge et al. (2016) and Vivien et al. (2019)

Vision Aligned Innovation Were More Often Eco-Innovation

	Non-Eco-Innovation	Eco-Innovation
Bioeconomy Vision	45	214
Vision Neutral	136	132

$\chi^2 = 63.579$, df = 1, $p < 0.05$.

Figure 2: Count of Eco-Innovation Types by Bioeconomy Vision

Bioresource Was Biggest Vision Category

But most innovations did not align with any vision

Figure 3: Counts of innovation classification by Bioeconomy Vision Category

Bioresource Vision

1970-1990:

Intensification of Harvesting

Energy & Chemical Pollution Reduction in Pulp and Paper

2000-2021:

New Materials

Bioresource

1970-1990:

Intensification of Harvesting

Energy Usage & Chemical Pollution Reduction in Pulp and Paper

2000-2021:

New Materials

Biotechnology

Mostly applications to clean water in pulp and paper

New materials from cellulose

Bioecology

74% Recycling related

Decommodification of value chains through regional identity products

Result Summary

1. The bioeconomy is declining relative to total innovation
2. Positive directionality towards bioresource vision, but overlap between visions and open development paths

Collaboration and Power

RQ

1. How collaborative is the innovation system ?
2. Which innovation system actors exercise most power?

Theoretical Framework & Data

Typology of Power Relations (Avelino, 2011, p. 75)

Relation Type	Manifestation of Power Relations		
More / Less Power	**Cooperation** A exercises more power than B, but collective goals	**Competition** A exercises more power than B, but mutually exclusive goals	**Co-existence** A exercises more power than B, independent co-existent goals

Collaborations identified through SWINNO. Firm aggregation a challenge ▶ disaggregated

Bioeconomy Innovation Producer Network Summary

Network	Nodes	Links	Average Degree	Density
1970-1983	87	64	1.47	0.02
1984-1990	52	40	1.54	0.03
1991-2008	78	65	1.67	0.02
2009-2021	35	27	1.54	0.05
Total	231	196	1.70	0.01

Output and Innovation Producers Declined

Figure 4: Plot of Nodes, Average Degree and Innovation Output Over Time for Bioeconomy Innovations and SWINNO Innovations.

The Innovation Producer Network Was Highly Fragmented

Figure 5: Network of bioeconomy collaboration over time. Gray circles indicate final network.

Most Powerful Bioeconomy Innovation Producers Included Sweden’s Biggest Companies

Which are more active producing innovation for non-bioeconomy purposes

Figure 6: Innovation Experience of 10 Most Connected Actors.

Result Summary

3. Bioeconomy innovation producer network highly fragmented and shrinking after 1980
4. Most powerful innovation producers more active outside bioeconomy

Thesis Outline

Take Aways

1. The bioeconomy is declining relative to total innovation
2. Positive directionality towards bioresource vision, but overlap between visions and open development paths
3. Bioeconomy innovation producer network highly fragmented and shrinking after 1980
4. Most powerful innovation producers more active outside bioeconomy

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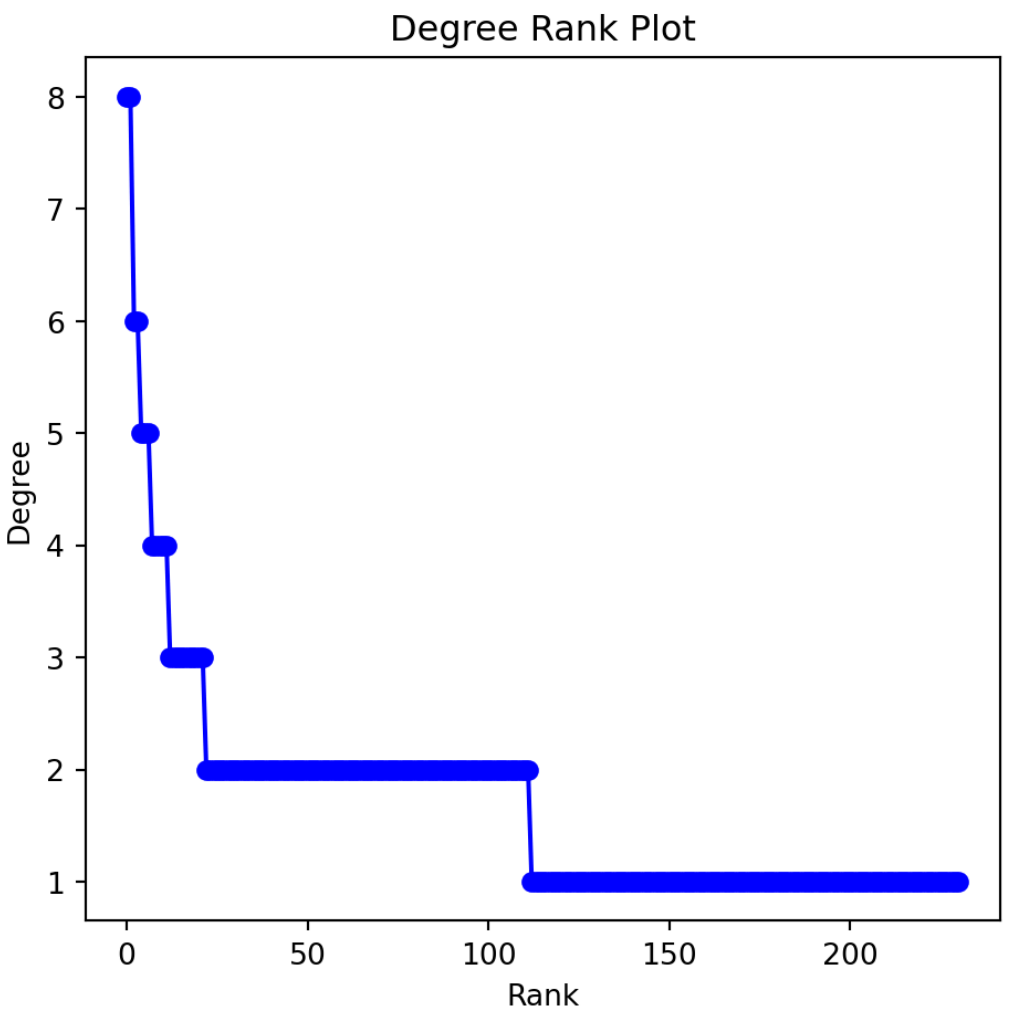
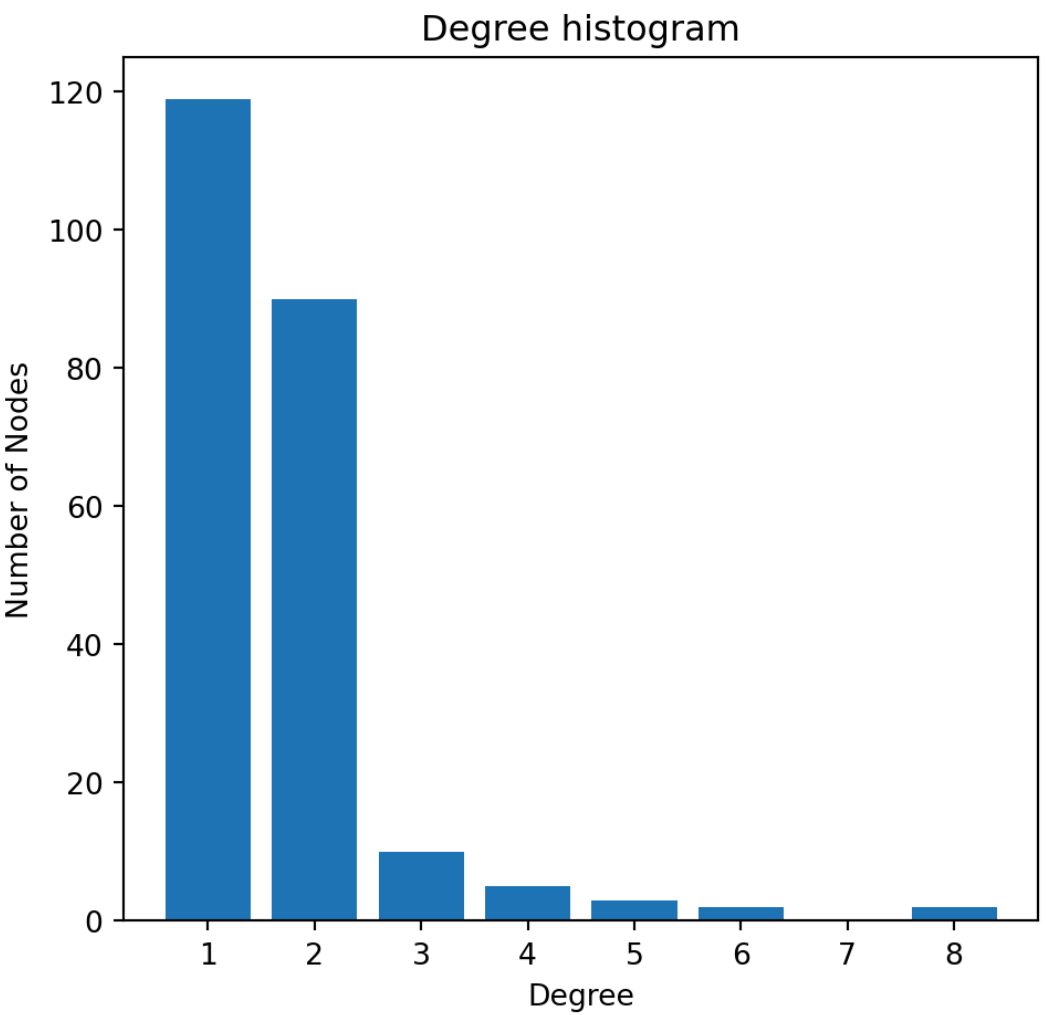
Appendices

Appendix Collaboration and Power

Bioeconomy Degree Distribution





▶ Bioeconomy network

Embedded Network

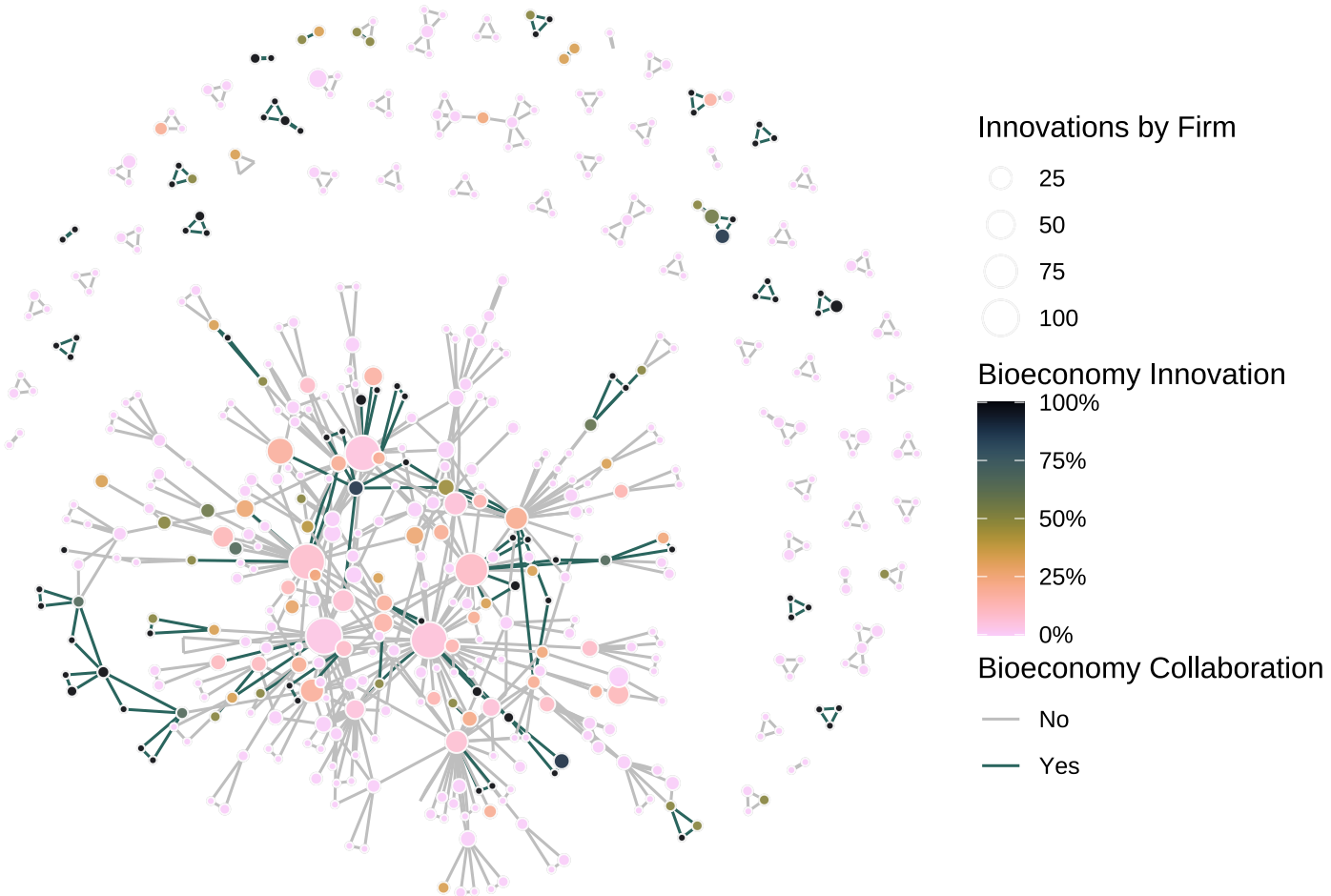


Figure 7: Network of all innovation in database. For better clarity, only nodes with more than 1 collaboration are shown. Sizes of individual nodes correspond with cumulated total innovation. Fill color shows a company's share of innovation within the bioeconomy compared to its total innovation in SWINNO data. Collaborations resulting in a bioeconomy innovation are highlighted in color.

▶ Bioeconomy network

The 10 Most Connected Nodes – Disaggregated

Network	Nodes	Links	Average Degree	Density
1970-1983	94	75	1.60	0.02
1984-1990	63	68	2.16	0.03
1991-2008	97	100	2.06	0.02
2009-2021	85	116	2.73	0.03
Total	318	359	2.26	0.01

Output and Innovation Producers Declined – Disaggregated

Figure 8: Plot of Nodes, Average Degree and Innovation Output Over Time for Bioeconomy Innovations and SWINNO Innovations.

Bioeconomy Network – Disaggregated

Figure 9: Network of bioeconomy collaboration over time. Gray circles indicate final network.

Embedded Network – Disaggregated

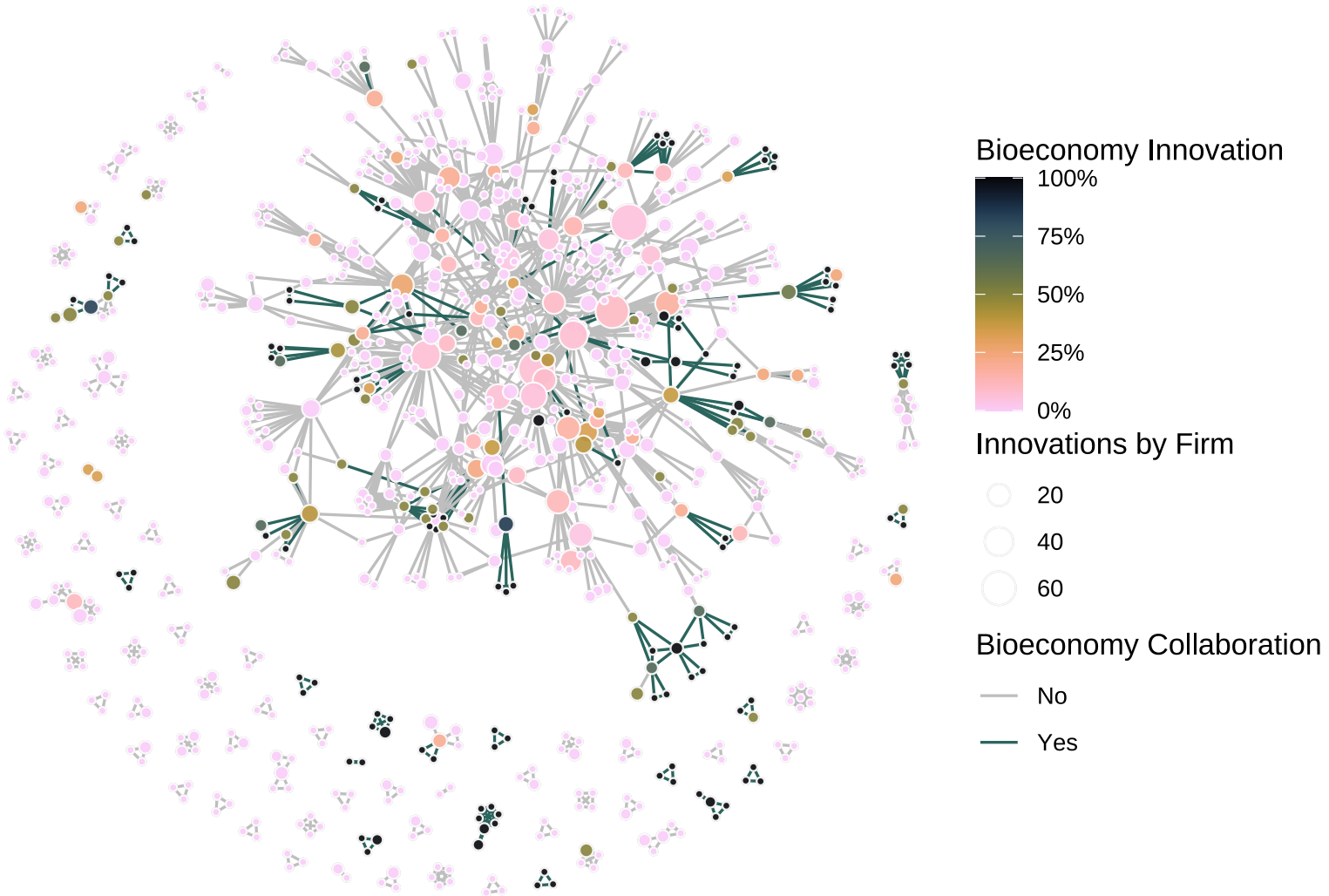


Figure 10: Network of all innovation in database. For better clarity, only nodes with more than 1 collaboration are shown. Sizes of individual nodes correspond with cumulated total innovation. Fill color shows a company's share of innovation within the bioeconomy compared to its total innovation in SWINNO data. Collaborations resulting in a bioeconomy innovation are highlighted in color.

Most Powerful Nodes – Disaggregated

Figure 11: Innovation Experience of 10 Most Connected Actors.