How Do Network Externalities Lead to Intergroup Inequality?

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Basic Idea:

Inequality among groups is exacerbated by the diffusion of practices that...

...can help you get ahead, and

...are more valuable if your friends do them (**network externalities**), and

...spread within networks whose members are similar to one another (**homophily**)

Two cases:

1. What are the limits of Internet diffusion? (computational model)

2. Why is migration so much greater in some Thai villages than others? (empirical analysis)

First Example: The Telephone

1892: John F. Parkinson, businessman and civic leader, becomes first telephone subscriber in Palo Alto, California. Uses it to call suppliers.*

1893: Realtor and butcher get phones; pharmacist offers pay phone service in a small room set aside for that purpose.

1897: 19 subscribers, including several home subscribers – Parkinson, two newspaper editors, and two physicians

1920: Almost 50 percent of Palo Alto homes have telephone – mostly homes of business people, merchants, and professionals – self-employed tradesmen follow by 1930…

*From Claude Fischer, *America Calling*

Second Example: AP Courses

There is substantial inequality in who takes Advance Placement (AP) courses in high schools.

Network externalities: Having friends who are taking AP courses reduces the costs (and increases the benefits) of taking them.

Homophily: High-school networks are notoriously segregated by class and race.

Positive advantages of networks flow disproportionately to those already advantaged.

Source: Maureen Hallinan, “Whatever Happened to the Anti-Tracking Movement”

Network Externalities

Definition: A product, service or behavior has network externalities if its value to an actor is conditional on the number of other actors who consume it.

Distinction:

General– you don't care who else is in the network.

Identity-specific – you only benefit if your network alters are participating.

Homophily

Definition: Social networks are homophilous with respect to a characteristic to the extent that pairs of actors in the network share the characteristic in question.

Prior work shows that homophily…

…is pervasive in social networks, and

…can be a barrier to diffusion (Rogers, 2003)

Diffusion Models

Prior work models...

...interdependence in consumer demand - bandwagon and snob effects (Leibenstein, 1950)

...adoption dynamics over time (Coleman et al., 1957)

...distribution of thresholds (Granovetter, 1978)

Our model is different because we consider...

...influence from specific network alters,

...homophily, and

...group-specific rather than aggregate diffusion paths.

The Argument

Diffusion processes of practices...

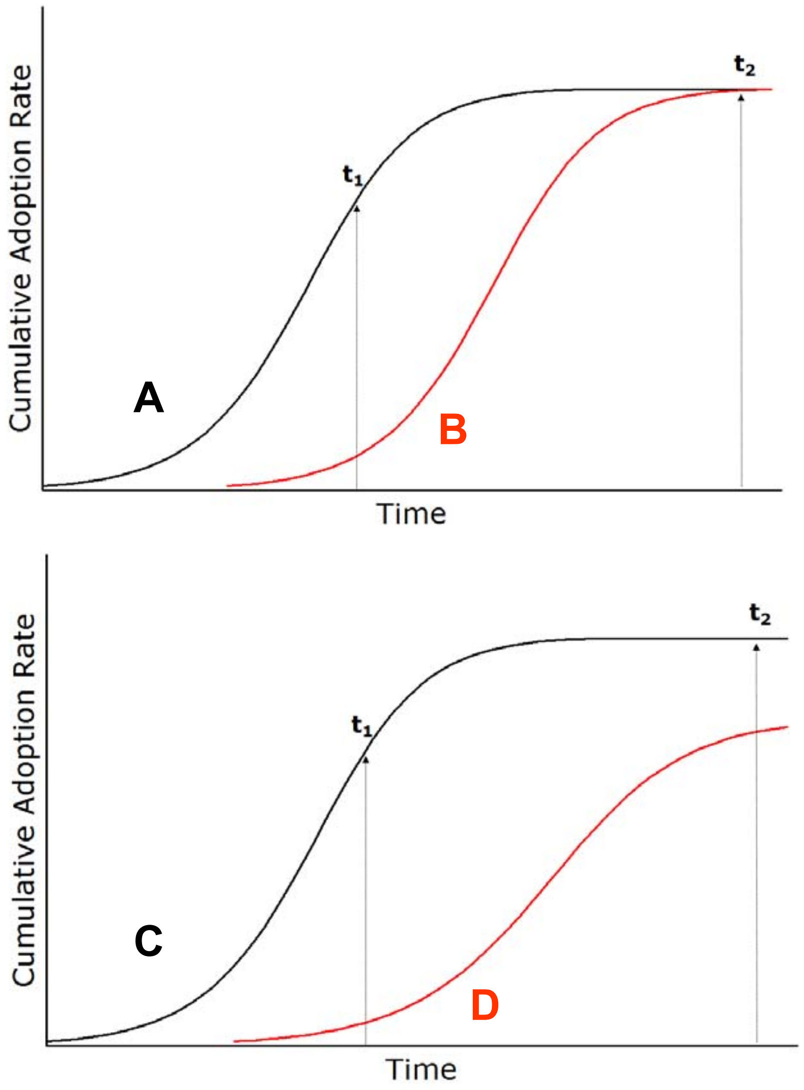
...with strong, identity-specific network externalities,

...under conditions of status homophily,

exacerbate social inequality by amplifying initial advantages and disadvantages.

Case 1: Diffusion of Internet Adoption

Transitional Inequality or Permanent Divide?



At time t_1, it is not clear whether one is in the top or bottom graph...

...unless one understands the mechanisms that generate the curves

Modeling Network Externalities

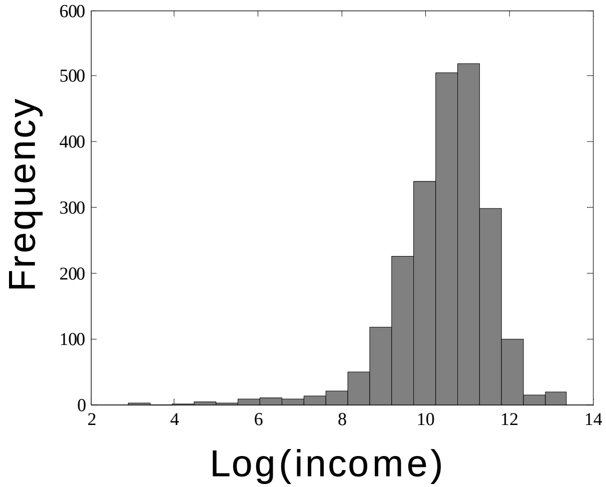
Agents' **race**, **income**, **education** and **network size** sampled from GSS (*N*=2,257)

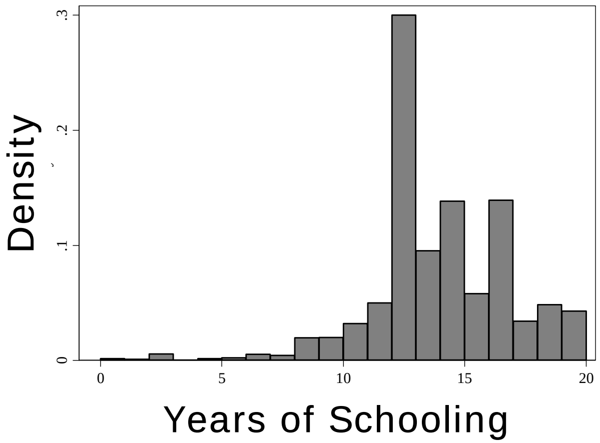
Distribution of Key Characteristics

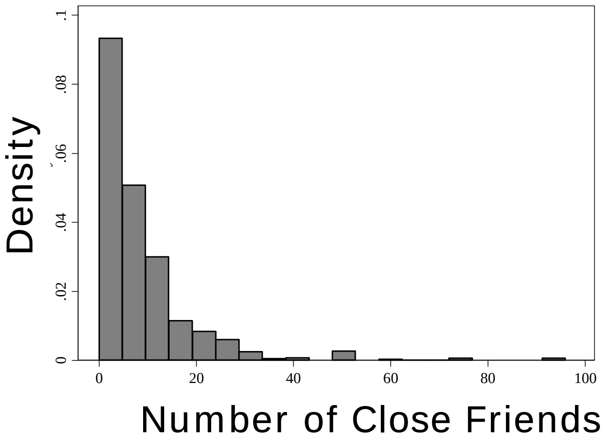
Race:

85% Whites

15% African Americans







Modeling Network Externalities

Agents' **race**, **income**, **education** and **network size** sampled from GSS (*N*=2,257)

Agents have a **reservation price**: *f*(income, network adoption).

Reservation Price Model

$$r_{it} = \underbrace{k \cdot y_i^{\gamma}}_{\text{Pure income effect}} + \underbrace{y_i^{\gamma} \cdot \delta \cdot n_{it-1}^{\alpha}}_{\text{Network effect}} + \varepsilon_{it}$$

Economides & Himmelberg (1995)

y_i	income of individual *i*
n_{it-1}	proportion of adopters in ind *i*'s network at time *t-1*
γ	exponent of income (0,1)
α	exponent of proportion of adopters (0,1)
k, δ	multiplicative constants
ε_{it}	random perturbation for individual *i* at time *t*

Modeling Network Externalities

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Internet price declines with network size

Internet Price Model

$$p_t - p_{t-1} = \underbrace{a \cdot n_{t-1}}_{\text{Speed of reversion}} \left(p_{\min} - p_{t-1}\right)$$

p_t	price at time *t*
p_{min}	equilibrium price
n_{it-1}	proportion of adopters in network at time *t-1*
a	multiplicative constant

Modeling Network Externalities

Agents' **race**, **income**, **education** and **network size** sampled from GSS

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Agents purchase Internet if **reservation price ≥ Internet price**

Agents adopt due to a combination of: (i) increasing reservation price and (ii) decreasing Internet price

Generating Networks with Homophily

Each agent has a **target number of ties**

Each dyad has a degree of **social distance**:
f(income, education, race)

$$sd(i,j) = \left\| I - J \right\| = \sqrt{(W_I(Inc_i - Inc_j))^2 + (W_E(Edc_i - Edc_j))^2 + (W_R(Race_i - Race_j))^2}$$

Generating Networks with Homophily

Each agent has a **target number of ties**

Each dyad has a degree of **social distance**:
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Ties are established such that **homophily bias** occurs with a *given* probability.

$$P(T) = \tau + [1 - \tau].\, P_R(T)$$

Skvoretz (1990)

$P(T)$	probability of an in-group tie
$P_R(T)$	probability of a random tie
τ	probability of homophily bias

Implementing the Model of Internet Diffusion

Generate a network with chosen degree of homophily *h* [0,1]

At each time period *t* in 1:100,

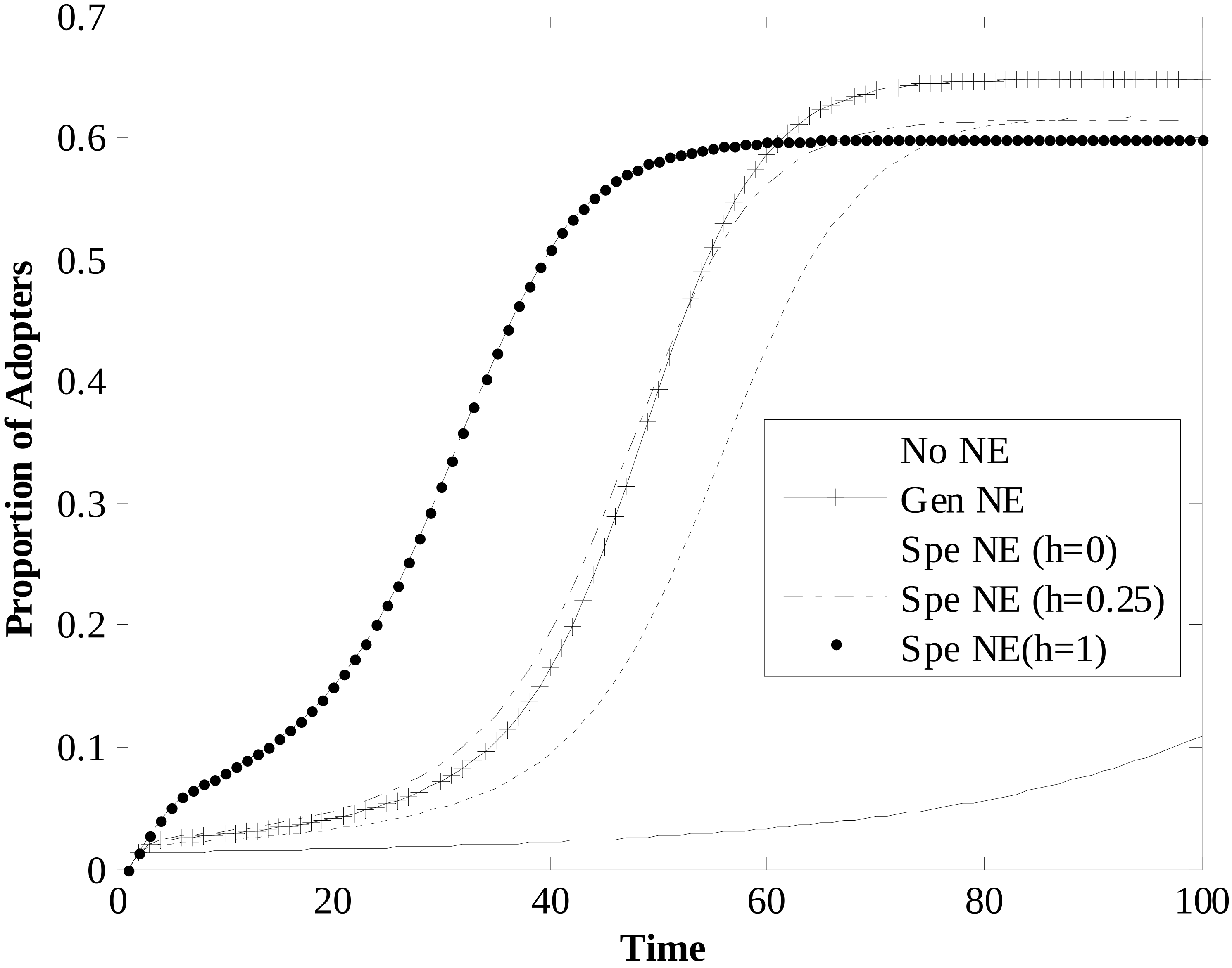
Identify the adopters (reservation price ≥ Internet price),

Update network adoption rates, reservation prices and the price of Internet service.

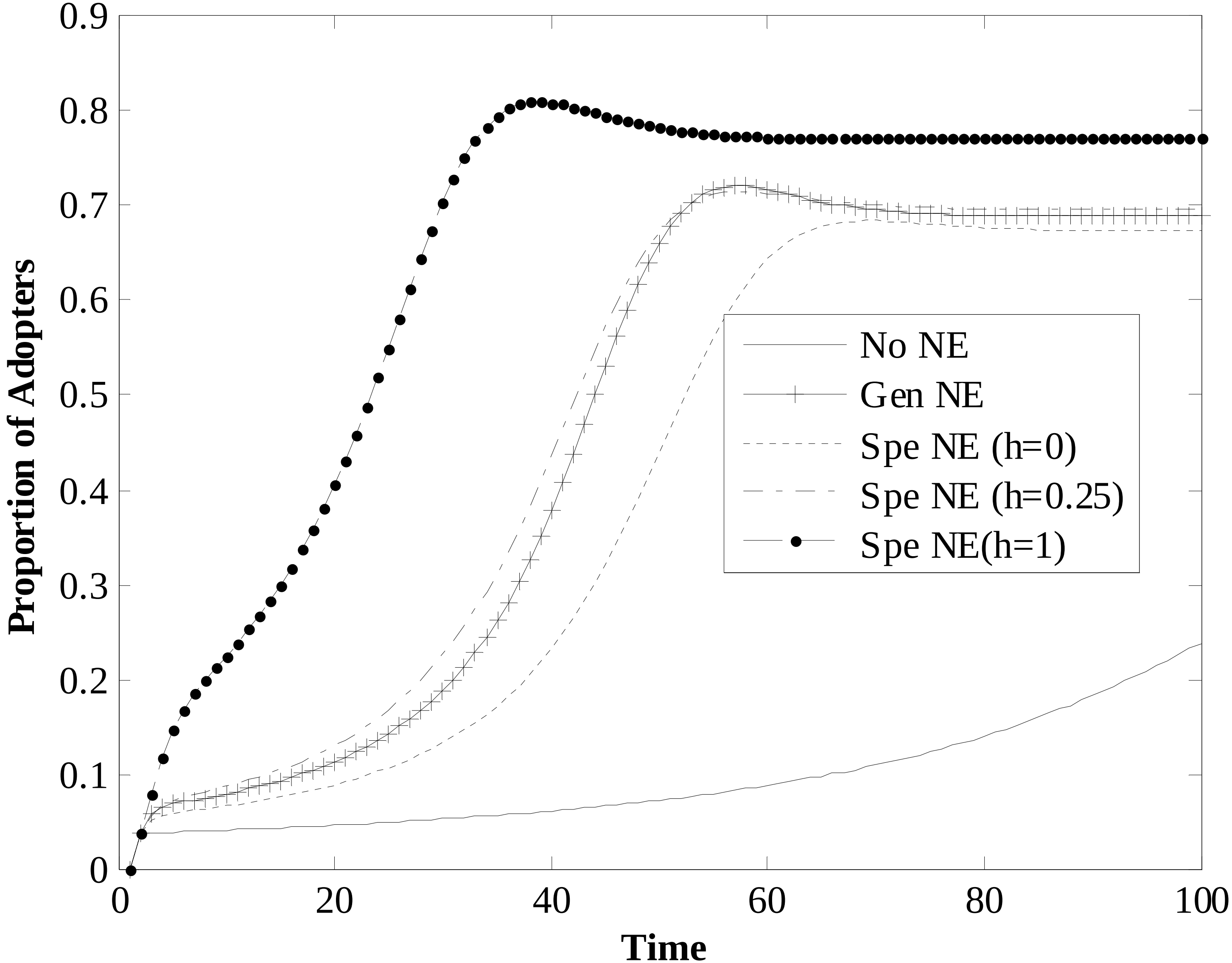
Consider 5 scenarios:

	Network Externalities	Homophily
1.	None	-
2.	General	-
3.	Specific	-
4.	Specific	Some (*h=0.25)*
5.	Specific	Total (h=1)

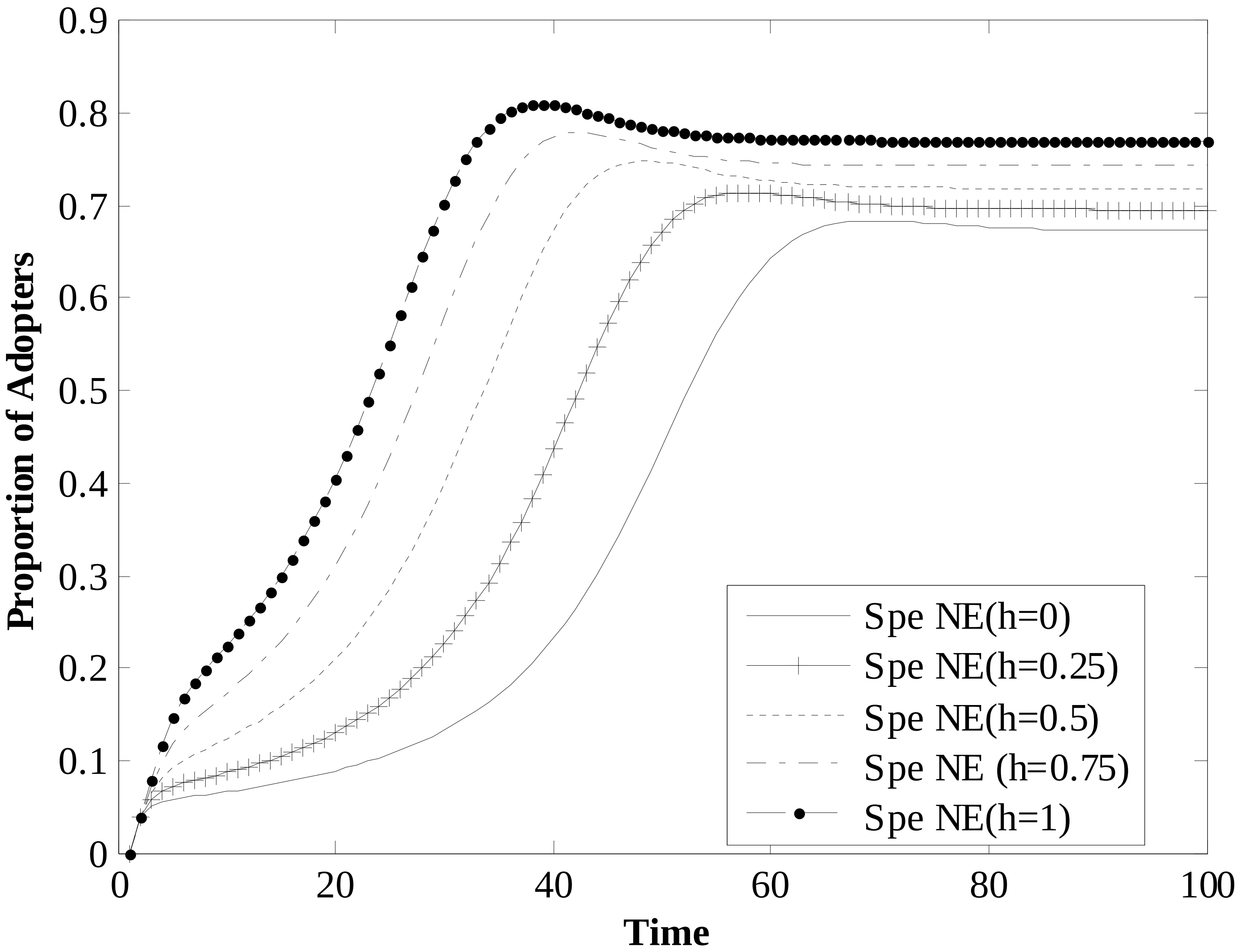
Diffusion under Externalities and Homophily



Differences b/w High and Low Income Groups



Differences b/w High and Low Income Groups by Homophily



Summary of Results on Internet Diffusion

Network externalities promote diffusion for population as a whole.

Specific network externalities under conditions of homophily...

> ...steepen slope of diffusion at low levels of homophily
>
> ...benefit privileged groups and increase intergroup inequality, proportionately as homophily increases.

Network Externalities in Migration

Networks ties to prior migrants...

decrease the costs and risks of migration,

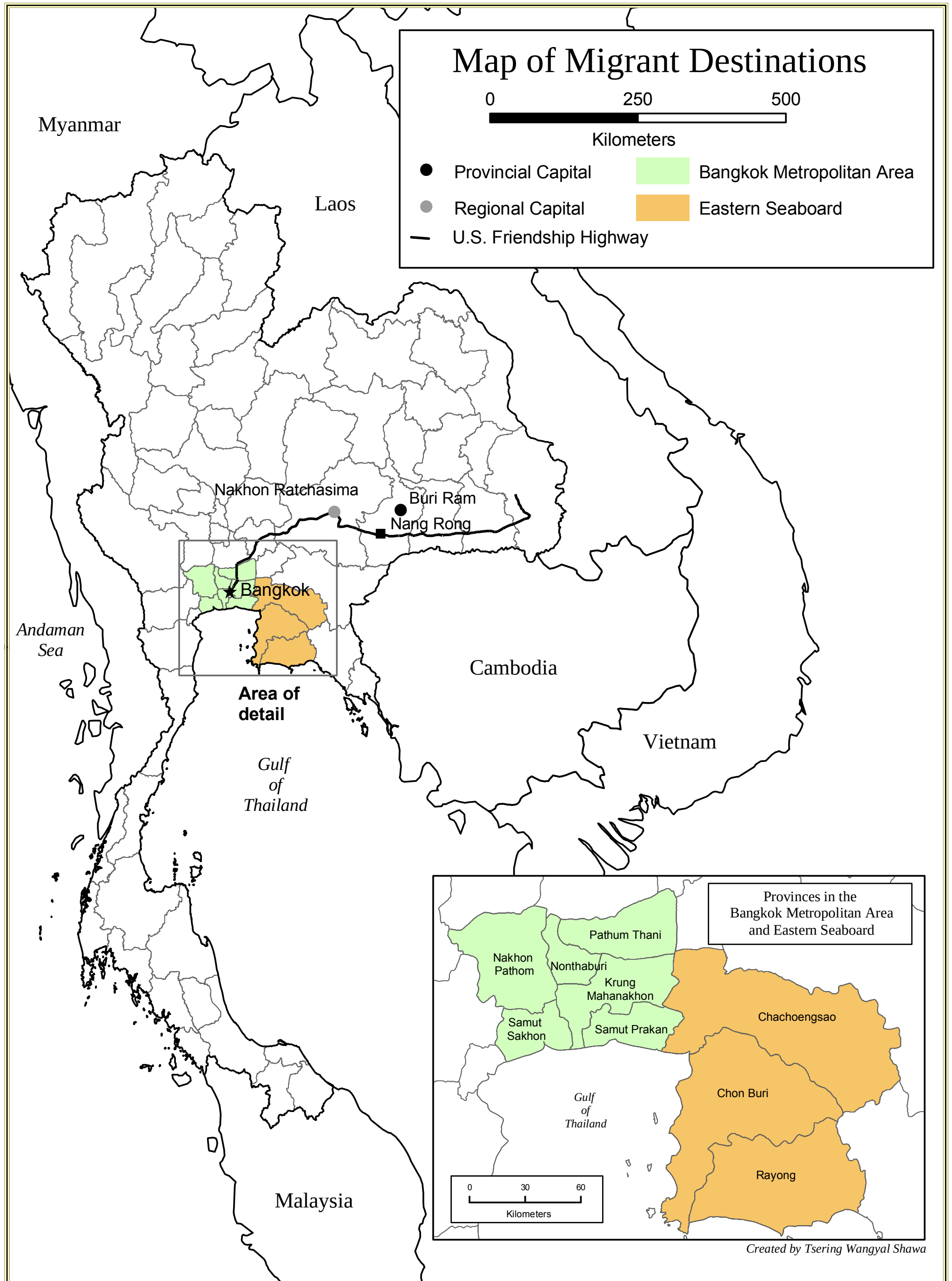
initiate a process called cumulative causation (Massey 1990).

Cumulative causation...

explains why migration flows persist, but

fails to explain why migration flows differ across communities.

Heterogeneity in migration patterns presents a puzzle that cannot be explained with current theories of migration.


Map of Migrant Destinations
0
250
500
Kilometers
Provincial Capital
Regional Capital
U.S. Friendship Highway
Bangkok Metropolitan Area
Eastern Seaboard
Myanmar
Laos
Nakhon Ratchasima
Buri Ram
Nang Rong
Bangkok
Andaman Sea
Cambodia
Area of detail
Vietnam
Gulf of Thailand
Malaysia
Provinces in the Bangkok Metropolitan Area and Eastern Seaboard
Pathum Thani
Nakhon Pathom
Nonthaburi
Krung Mahanakhon
Samut Sakhon
Samut Prakan
Chachoengsao
Chon Buri
Rayong
Gulf of Thailand
0
30
60
Kilometers
Created by Tsering Wangyal Shawa

Thai Setting

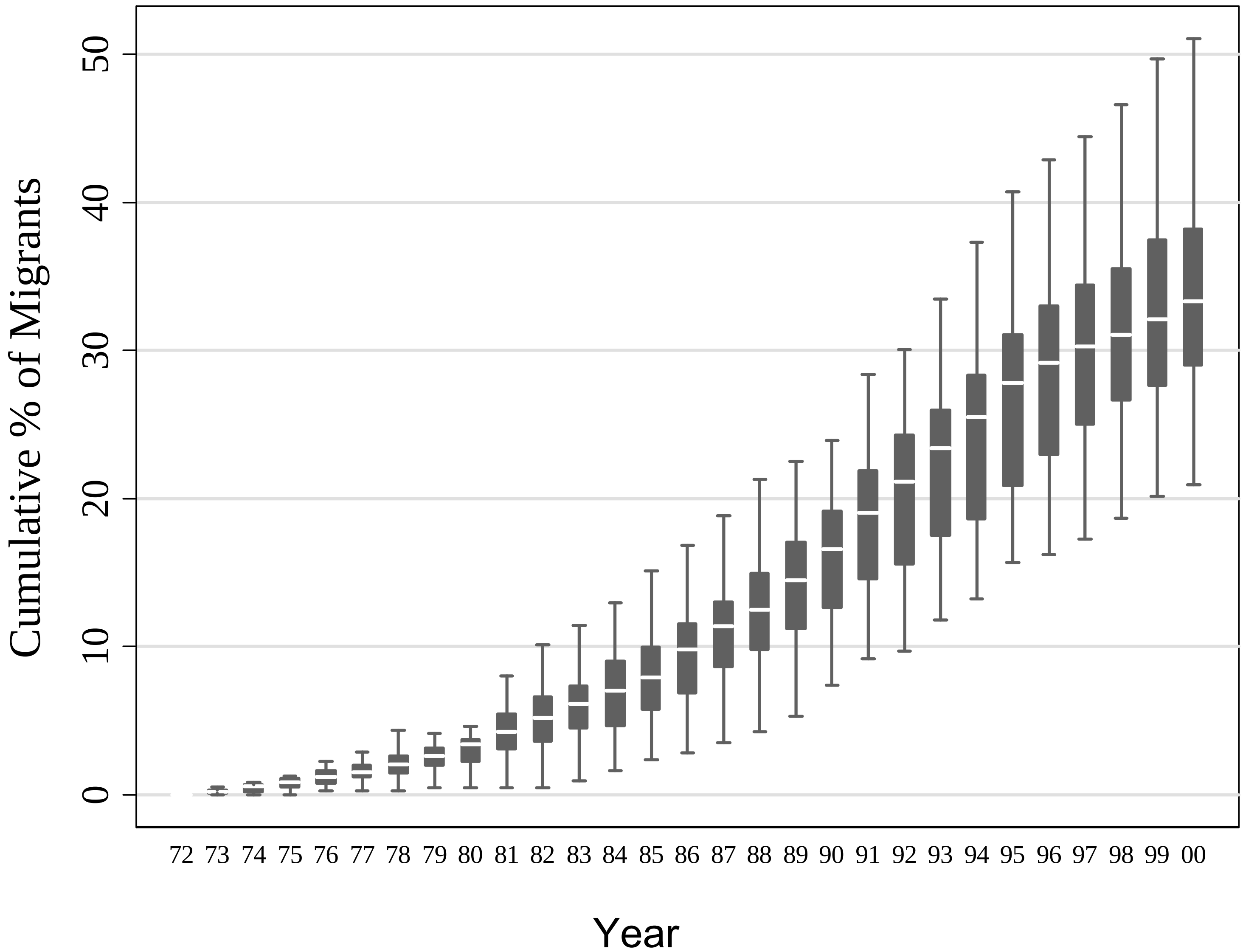
Dramatic economic change and growth from 1980s to mid-1990s

Shift of the economic base from agriculture to export processing

Increased rural to urban migration

Nang Rong Survey Data: Life histories of <u>all individuals</u> aged 13-35 in 22 villages between 1972 and 2000

Inequality in the Diffusion of Migration in 22 Nang Rong Villages (1972-2000)



Network Externalities, Homophily and Migration

Three diffusion channels for migration: household, village, and Nang Rong

Specific networks (household and village) will have a higher positive impact on migration than general networks (Nang Rong).

Social homogeneity will decrease the diversity of information, and decrease migration.

Social homogeneity will moderate the impact of networks on migration.

Impact of Networks on Migration

	Hazards Ratio
Number of prior migrants...	
in the household	1.077 *
in the village (excl. hh)	1.001 *
in Nang Rong (excl. vill)	1.000 *
N (person-years at risk)	50,198

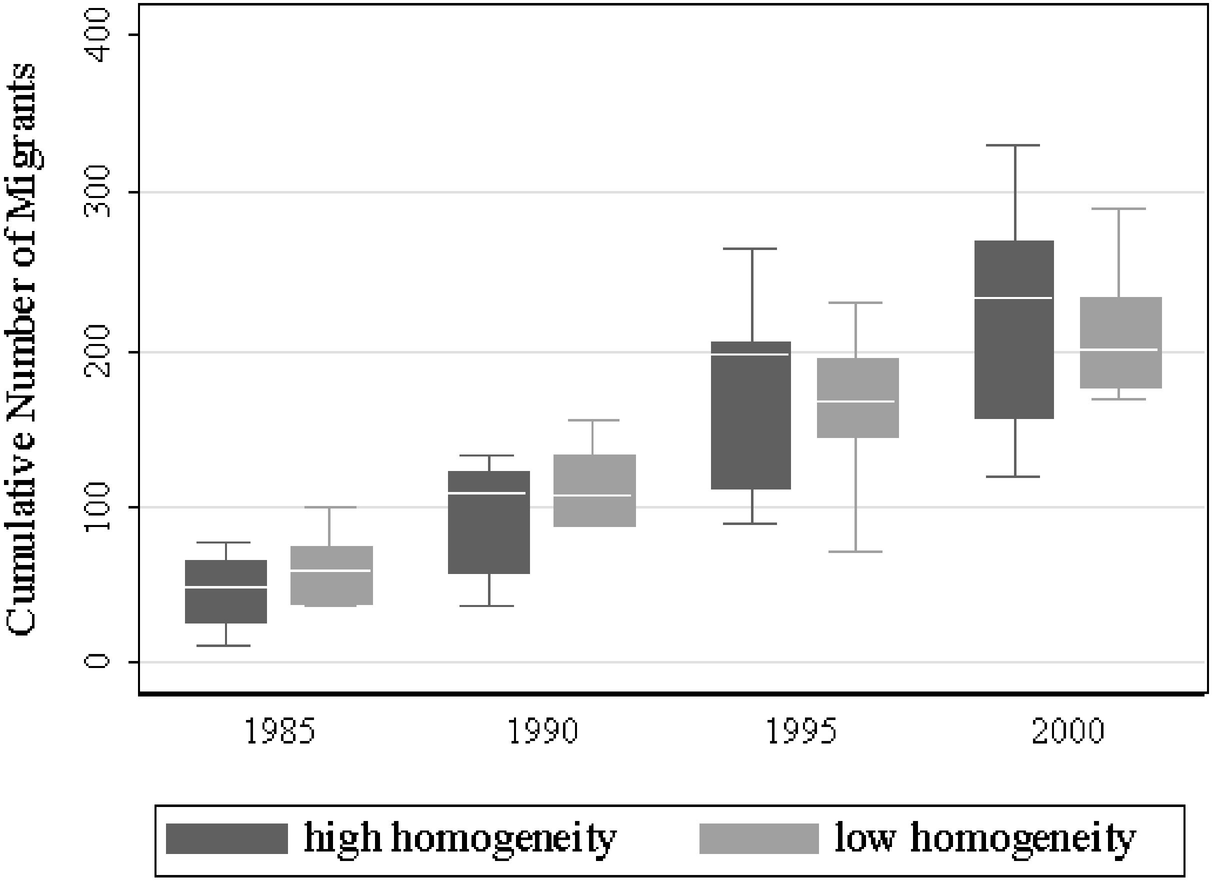
*p<0.01 Includes controls for age, sex, education, marital status, wealth, household structure, and village development indicators.

Impact of Networks and Homogeneity on Migration

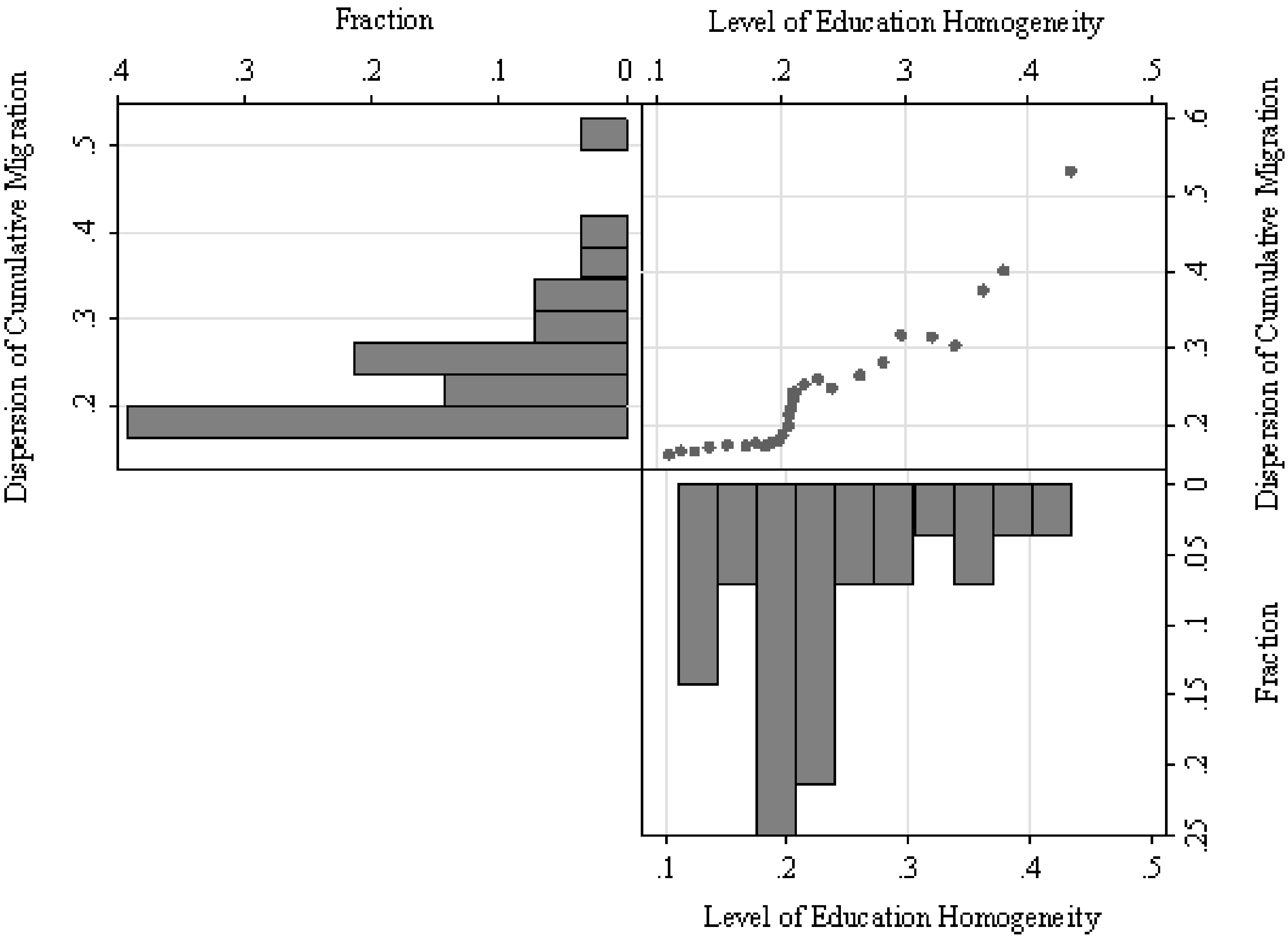
	Homogeneity in	
	Education	Occupation
Number of prior migrants...		
in the household	1.061 *	1.048 *
in the village (excl. hh)	0.995 *	0.993 *
in Nang Rong (excl. vill)	1.000	1.000
Homogeneity in year [0,1]	0.030 *	0.126 *
Homogeneity * No of prior migrants	1.037 *	1.025 *

*p<0.01 Includes controls for age, sex, education, marital status, wealth, household structure, and village development indicators. Also includes indicators of mean education level in the village, and percent working in each occupation.

Dispersion of Migration across 22 villages by Education Homogeneity



Dispersion of Migration across 22 villages vs. Level of Education Homogeneity



Conclusions – Internet Diffusion Model

The combination of specific externalities with homophily dramatically steepens the diffusion curve (compared to a process with only general externalities or a standard S curve). Modest homophily accomplishes this, with additional homophily having little additional effect.

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Deviations from observed data suggest that the actual process is based on a *mixture* of general and specific network externalities.

Conclusions – Migration Model

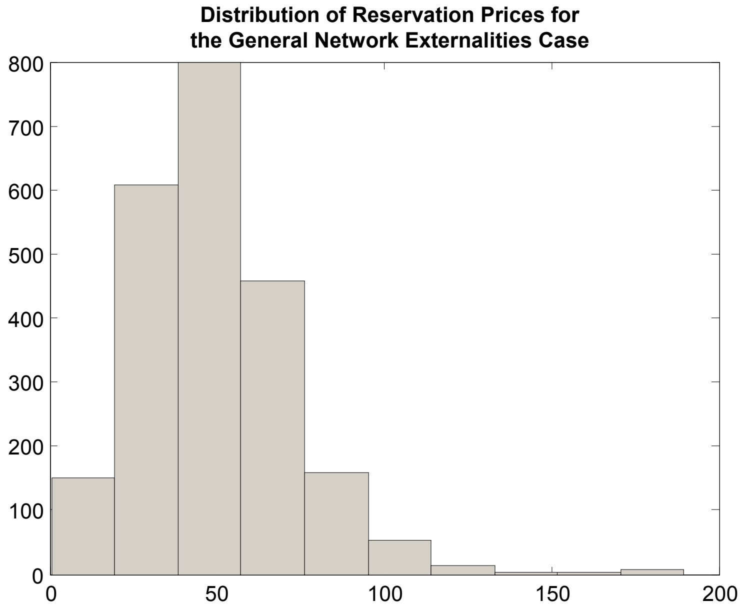
The results are consistent with the hypothesis that the posited mechanism is at work...

> Strong net effects of networks, especially local ones, on migration.

Village level: negative direct effects of homogeneity but positive interactions of homogeneity with networks.

Village level: homogeneous systems (presumably characterized by high structurally induced homophily) develop greater variance, consistent with accentuation of initial differences over time *via* network effects.

Model Parameters – Reservation Price

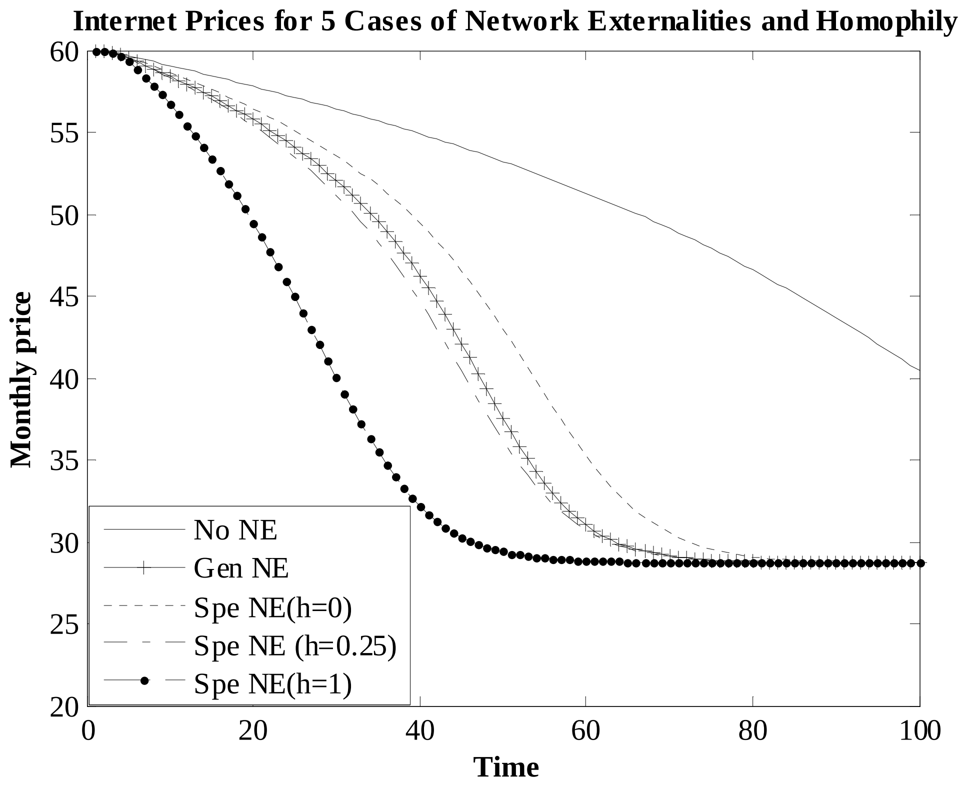


$$r_{it} = 0.1 \cdot y_i^{0.5} + 0.1 \cdot y_i^{0.5} \cdot n_{it-1}^{0.5} + \varepsilon_{it}$$

$$\varepsilon_{it} \sim N(0,12.5)$$

Assigned (based on results from a calibration exercise on *reduced model* using OECD data)

Model Parameters – Internet Price



$$p_t - p_{t-1} = \frac{3.34}{12} \cdot n_{t-1}\left(28.74 - p_{t-1}\right)$$

$$p_0 = \$60$$

Estimated using OECD data 1998-2000

Network Simulation Pseudo-Algorithm

Set inbreeding bias, τ=a constant in [0-1]

Generate N Nodes

For each node

- Assign Race, then Income and Education
- Assign Target Ties (by income, education and race)
- Compute social distance and determine in-group members

End

Pick a node

While (Current Ties)<(Target Ties)

- Generate a uniform random number, u
- If ($u < \tau$) (inbreeding bias occurs)
- Pick a node from the in-group with (Current Ties) < (Target Ties)

Else

- Pick a node at random with (Current Ties) < (Target Ties)
- Increment Current Ties for both nodes by 1

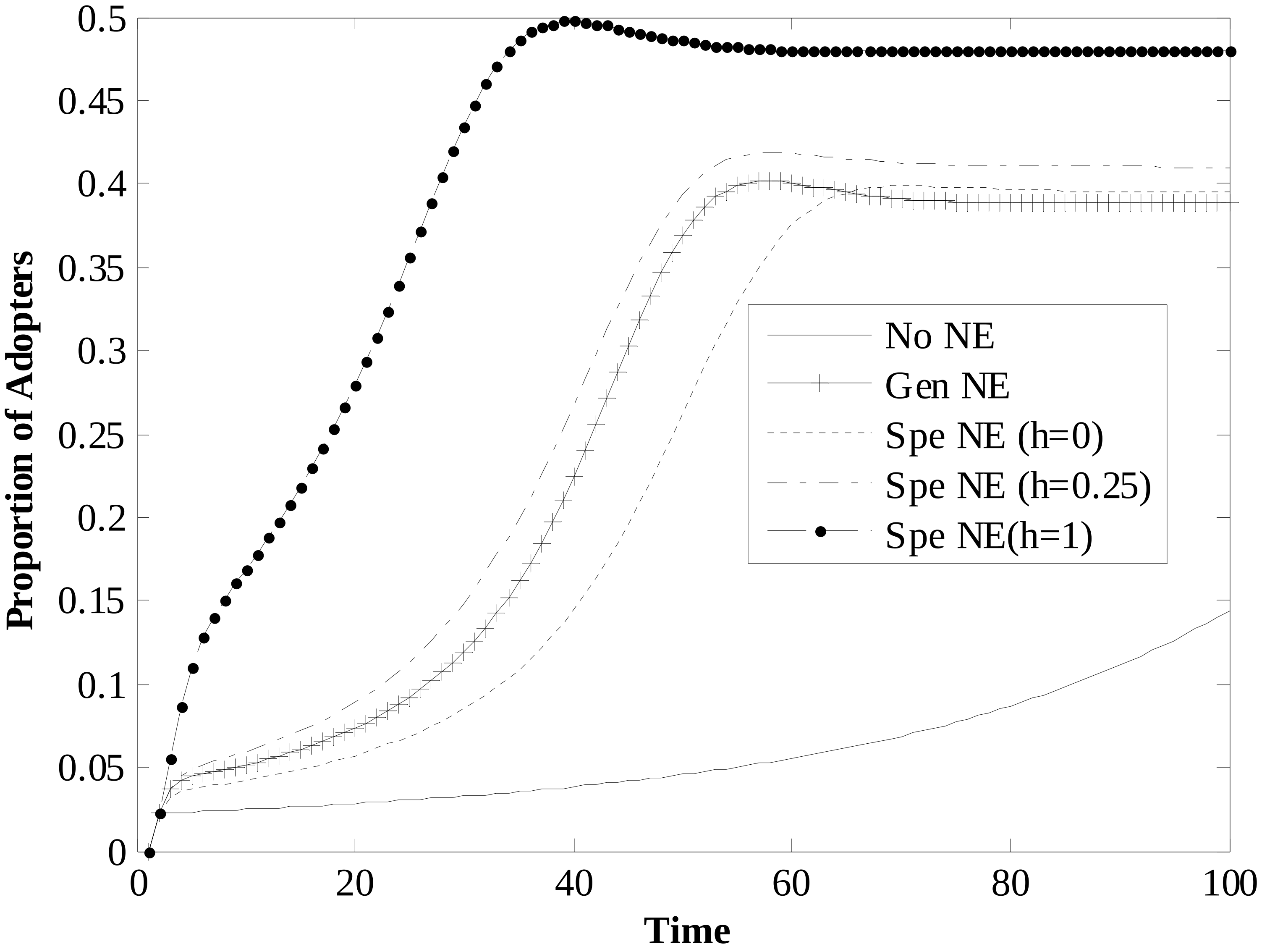
End

Repeat until for all nodes Current Ties = Target Ties

Internet Diffusion Pseudo-Algorithm

1. Generate a biased network with bias parameter, τ.
2. Simulate internet adoption for T time periods.
3. Save the number of adopters by time and subgroup (income/education/race).
4. Repeat steps 1-3 K times
5. Average number of adopters at time t (t=1,...,T), for each subgroup i (i=1,...,M) over K repetitions.
6. Change the bias parameter, and go to step 1.
7. Repeat steps 1-6 for three cases of adoption, with:
   - (a) no network externalities,
   - (b) general network externalities, and
   - (c) specific network externalities.

Differences b/w High and Low Education Groups



Differences b/w Whites and Blacks