Unraveling the Internal Complexity of a Metropolitan Economy

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Motivation and Collaboration

- In the last four decades, exploration of **horizontal spatial interdependence** has moved from estimation of spillover/feedback effects from interregional input-output models to embrace the more extensive tools of spatial econometrics
- The **vertical dimension** has remained relatively unexplored; recent work by Chung (2014) suggests that at a broad regional scale ignoring the vertical dimension may generate overestimates of the horizontal interactions (spatial spillovers)
- Current presentation part of a broader inquiry into how multiple levels of an economy interact in both a vertical and horizontal fashion

How do Regional Economies Grow?

- To answer this fundamental question that is at the core of regional economics, scholars looked at analyses of national economies for inspiration
- Borrowed from Harold Innes' (Canadian) notion of a staple theory of economic growth in which export activity generated, through the foreign trade multiplier, a stimulus for the creation and development of the local (domestic) economy
- If this worked at the national (international) level, could a similar formulation be considered at the sub-national or regional level?
- Innovation – division of local economy into endogenous and exogenous
- Started with economic base model (basic/export and non basic local)
- Extended with IO and CGE models

How do Regional Economies Grow (2)?

- The main innovation – division of local economy into **exogenous** and **endogenous**
- **Exogenous** **activities that were dependent on external markets**
- **Endogenous** **activities that sold good and services to the local market**
- Exogenous also referred to as the export or basic activity; endogenous as local or non-basic
- Geographers had a similar idea but never developed it beyond basic/nonbasic ratios
- Economists developed a formal model

How do Regional Economies Grow (3)?

- The Economic Base Model assumed that:
  - Nonbasic = f(basic)

- **Hoyt's Model**

$\frac{L_n}{L_T} = \alpha \rightarrow$ a share of total employment

$0 < \alpha < 1$

Total Employment $L_T = L_b + L_n$

Employment (base sector) (exogenous)

Employment (non-base sector)

$$\Rightarrow \quad L_T = \frac{1}{1-\alpha} L_b$$

> 1 : the multiplier

i.e. basic employment has the capacity to generate additional employment in the region

How do Regional Economies Grow (4)?

The Multi-Sectors Model

Input-Output **Multiplier** vs Economic Base **Multiplier**

- Economic Base Model
  - Single multiplier: $L_T = \boxed{\frac{1}{1-\alpha}}\ \bar{L}_b$
- Input-Output Model
  - Matrix of multipliers: $\mathbf{x} = \boxed{(\mathbf{I}-\mathbf{A})^{-1}}\mathbf{f}$
  - Ripple Effect: $(\mathbf{I}-\mathbf{A})^{-1} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \mathbf{A}^4 + \cdots$

How do Regional Economies Grow (5)?

- What is missing is these models?
  - Focus on the demand side – little is said about supply side (e.g. labor force participation rates, migration, supply of other factors of production)
  - Open models – income is earned but the impact of spending is not considered – the circular flow of income is incomplete
  - Assumes region is homogenous – change in one part of the region will generate the same impact as in another part e.g. a R$1 billion change in Ribeirão Preto is assumed to generate the same impact as a similar change in São Paulo city on the state of São Paulo
  - Use a Representative Household assumption – no differences in income receipt or expenditures based on location on household income levels

What is happening Inside Metro Regions?

- Krugman has argued that patterns and impacts of trade have similar impacts
  - Between countries
  - Between regions inside countries
- What about interaction **within** large metropolitan regions?
- Detailed analysis of the Chicago economy provides some insights into the nature and strength of trading relationships
  - Goods and services
  - Flows of people (commuting)
  - Flows of expenditures by households
- Important to understand how economies work prior to enacting policy or evaluating it – analyses here provide contribution to this dialog

Extended Demo-Economic Modeling

- Most important contribution of Miyazawa (1976) was his analysis of the structure of income.
- Parallel development to the demo-economic models of Batey and Madden
- Example of an "onion-skin" approach to demographic-economic (hereafter, demo-economic) impact analysis
- Link the demographic and economic parts of an economy, revealing the effects of:
  - changes in economic actions on income distribution, status in the labor force or migration behavior on the one hand and
  - the effects of changes in consumption spending, employment status and so forth on economic activities.

Extended Demo-Economic Modeling (2)

- Miyazawa considered the following block matrix:

$$M = \left(\begin{array}{c|c} A & C \\ \hline V & 0 \end{array} \right)$$

where $\boldsymbol{A}$ is a block matrix of direct input coefficients, $\boldsymbol{V}$ is a matrix of value-added ratios for some r-fold division of labor and non-labor categories and $\boldsymbol{C}$ is a corresponding matrix of consumption coefficients for the r-types of households.

In the open IO model only focus on $\boldsymbol{A}$

Extended Demo-Economic Modeling (3)

- Decomposing the Miyazawa matrix, *M*, yields:

$$(I - M)^{-1} = \left(\begin{array}{c|c} I & BC \\ \hline 0 & I \end{array}\right)\left(\begin{array}{c|c} I & 0 \\ \hline 0 & K \end{array}\right)\left(\begin{array}{c|c} B & 0 \\ \hline VB & I \end{array}\right) =$$

$$= \left(\begin{array}{c|c} B(I + CKVB) & BCK \\ \hline KVB & K \end{array}\right)$$

Where $B = (I - A)^{-1}$ is the Leontief inverse matrix

BC is a matrix of production induced by **endogenous** consumption

VB is a matrix of **endogenous** income earned from production

L=VBC is a matrix of expenditures from endogenous income

Extended Demo-Economic Modeling (4)

- The most important component:

$$K = (I - L)^{-1} = (I - VBC)^{-1}$$

is the **Miyazawa interrelational income multiplier** or the generalized Keynesian multiplier

- Traces how income earned in one region or by one group generates income to other regions or groups
- Is it symmetrical or asymmetrical – impact of income generated by region *R* on region *S* may be larger/smaller than the impact of *S* on *R*?

Application to Chicago

- In many metropolitan regions, conflicts between central cities and suburbs have been waged on the premise that neither area needs the other
- These assertions have gone unchallenged with little if any sound economic analysis to provide a foundation for their support or reputation.
- In this climate, inner city development is often seen as a zero-sum game, providing little demonstrable benefit to parts of the metropolitan region outside the targeted areas and commanding public resources with high opportunity costs that might be more effectively directed to other parts of the region.

Application to Chicago (2)

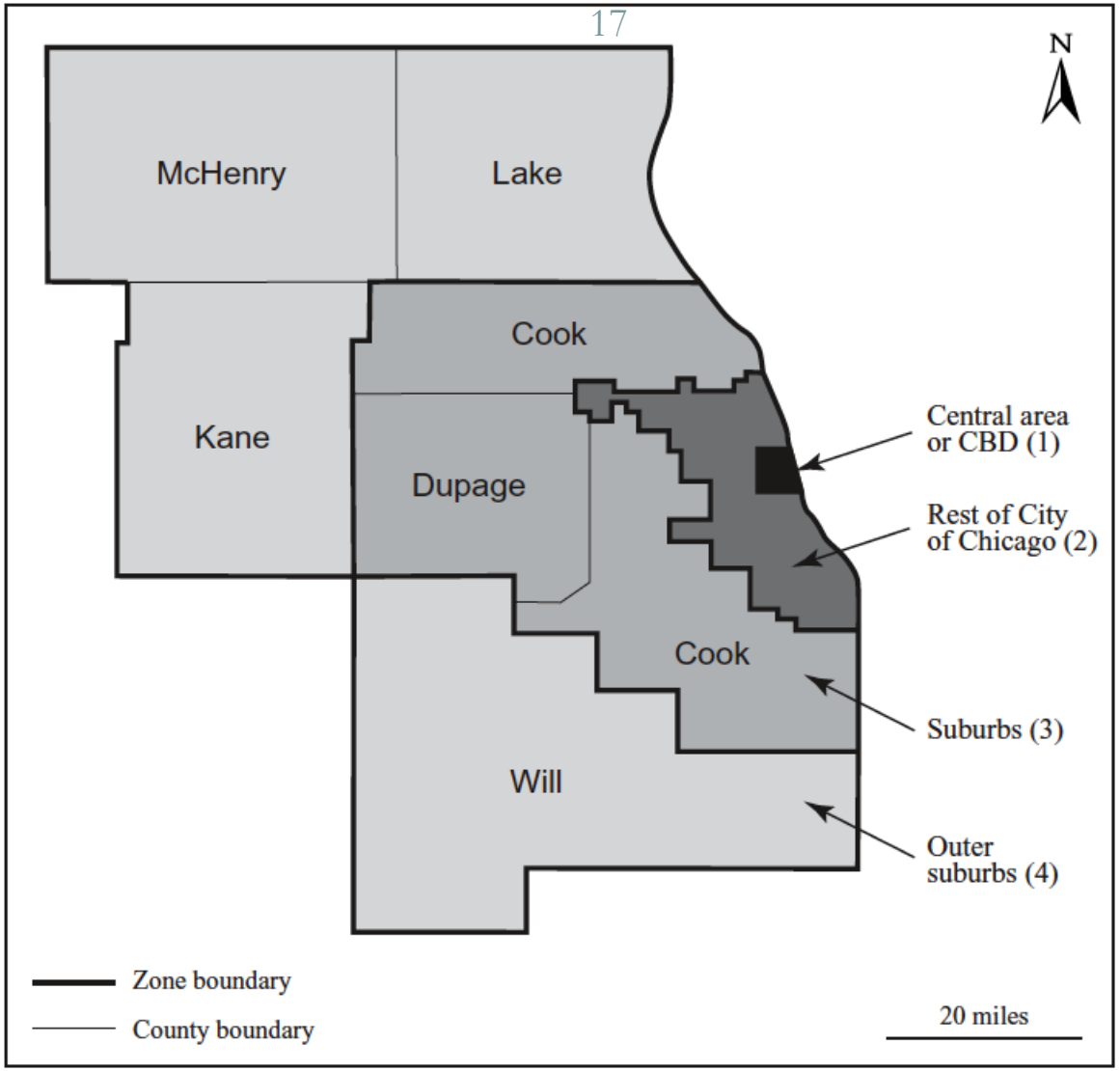
- Little formal analysis has been conducted to examine the nature, strength and type of any economic spillover and thus challenge the veracity of these assertions.
- **Yet, if there are gains from trade and interdependence in general between nations or between regions within a nation, should there not be some expectation of similar findings within a metropolitan region?**
- Chicago analysis attempted to develop an understanding and appreciation of the magnitudes of the economic relationships and economic interdependence between inner-city communities and the rest of the metropolitan area

Application to Chicago (3)

- Unlike trade between nations, this interdependence depends not only on:
  - the **movement of goods and services** but also on the
  - **movement of labor**, i.e., commuting and the
  - associated **income flows** (income earned in one part of the city is taken home to another part) and the
  - movement of consumers in the **spending of this income**
- In order to illustrate the complex interdependencies within a metropolitan area a 4-region multiregional input-output model was constructed using Miyazawa's (1976) extended framework.


Lake Michigan
MICHIGAN
INDIANA
IOWA
MISSOURI
KENTUCKY
INDIANA
ILLINOIS
Charles Mound
1235 feet
Freeport
Rockford
Waukegan
North Chicago
Palatine
Arlington Heights
Elgin
Skokie
Evanston
Chicago
De Kalb
Dixon
Sterling
Naperville
Aurora
Joliet
Rock Island
Moline
Chicago Heights
Peru
Ottawa
La Salle
Kewanee
Streator
Kankakee
Galesburg
Monmouth
Pontiac
Peoria
Canton
Macomb
Pekin
Normal
Bloomington
Rantoul
Havana
Lincoln
Champaign
Danville
Urbana
Beardstown
Quincy
Springfield
Decatur
Jacksonville
Pittsfield
Charleston
Mattoon
Pana
Jerseyville
Effingham
Alton
Vandalia
Carlyle Lake
Olney
Granite City
East St Louis
Salem
Centralia
Belleville
Mount Vernon
Rend Lake
Carmi
West Frankfort
Marion
Harrisburg
Carbondale
Cairo
Mississippi River
Illinois River
Kaskaskia River
Wabash River
Ohio River
State capital
Interstate Highway
Highway
Railroad
Miles
0
25
50
75
100

Spatial Division of Chicago



Chicago Intra Metropolitan Flows

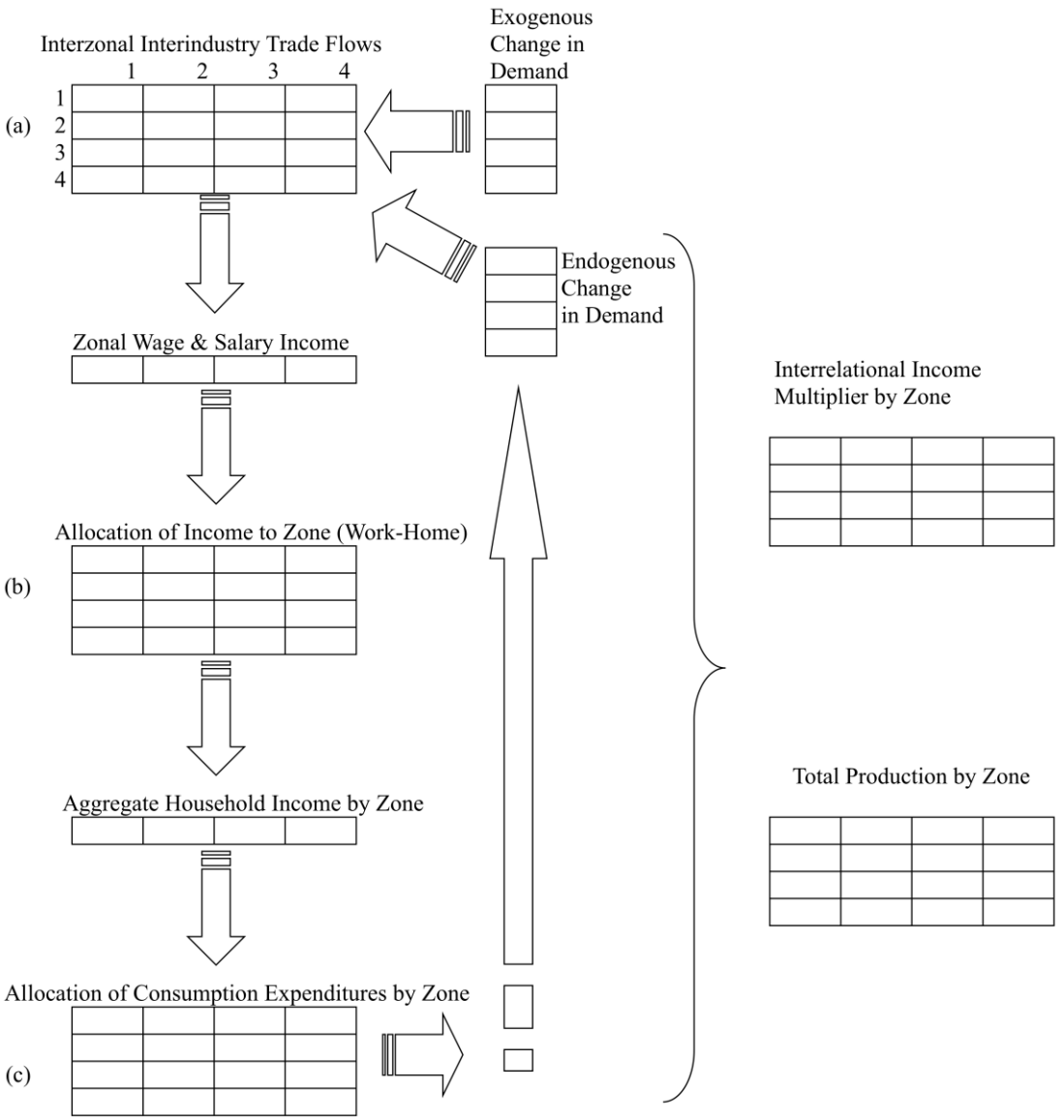
Goods and Services Flows

Wages and salaries

Flows of commuters and their incomes by zone

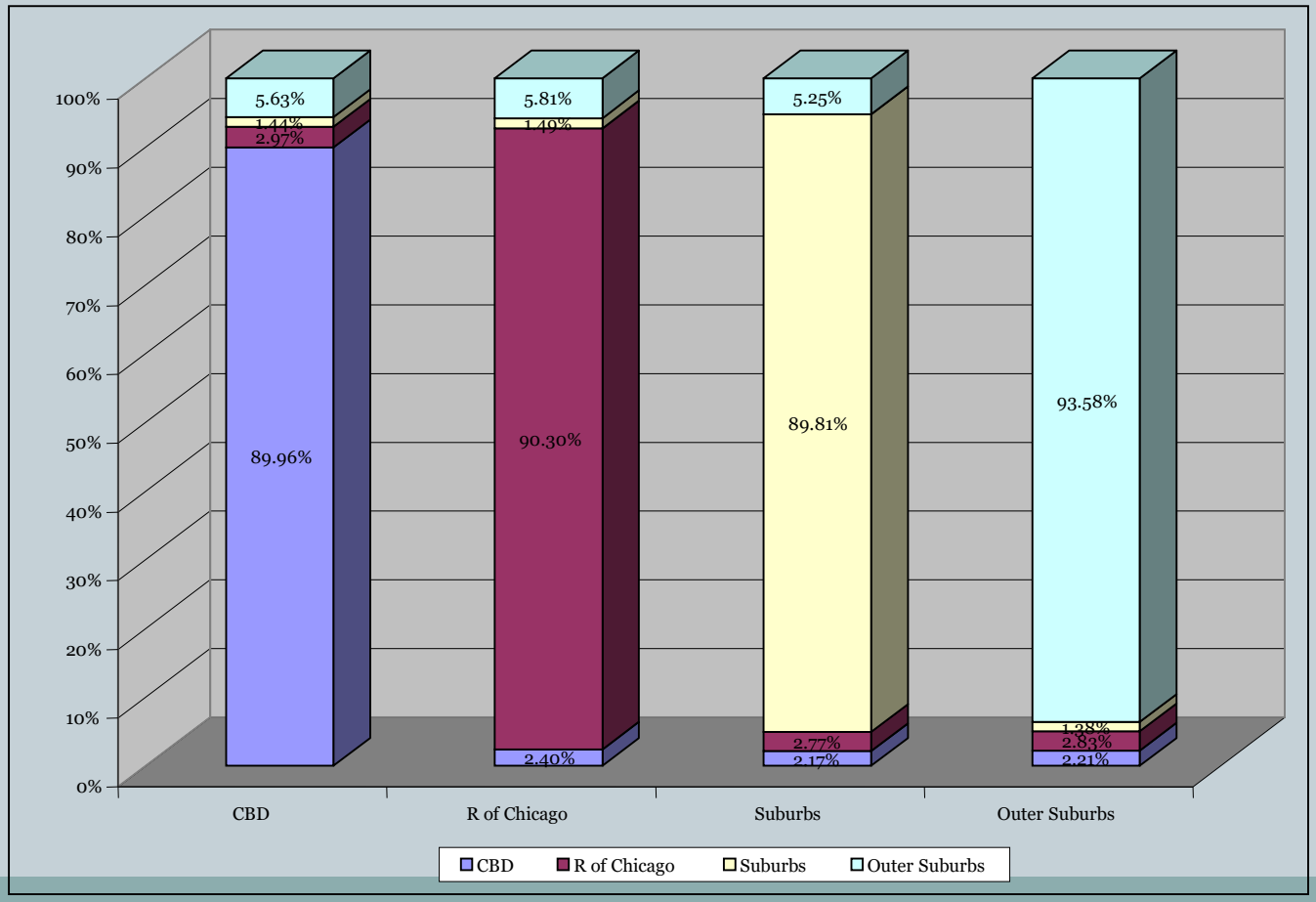
Household expenditures

Flows of total expenditures by zone



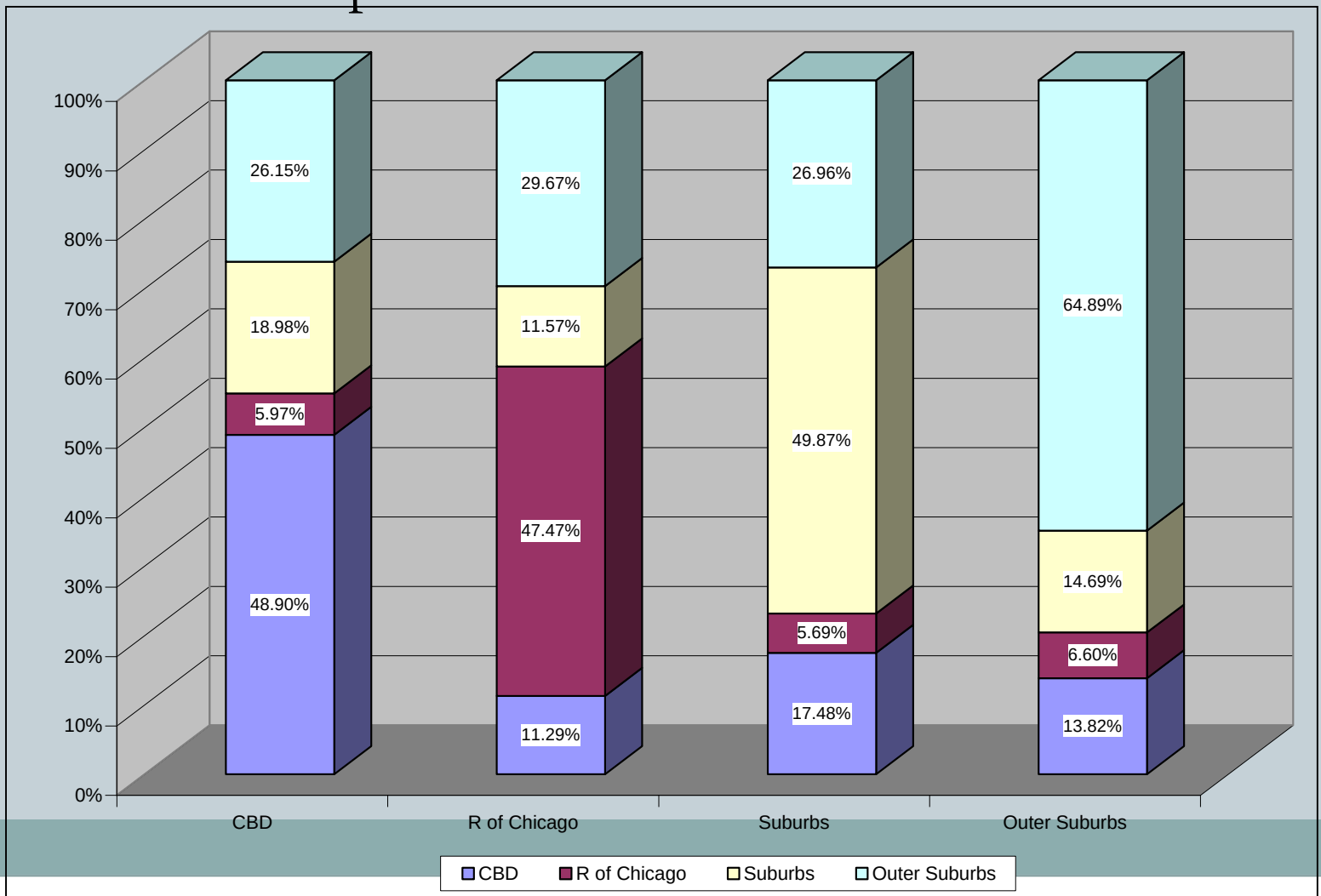
Interindustry Interdependence

- Limited connections across regions

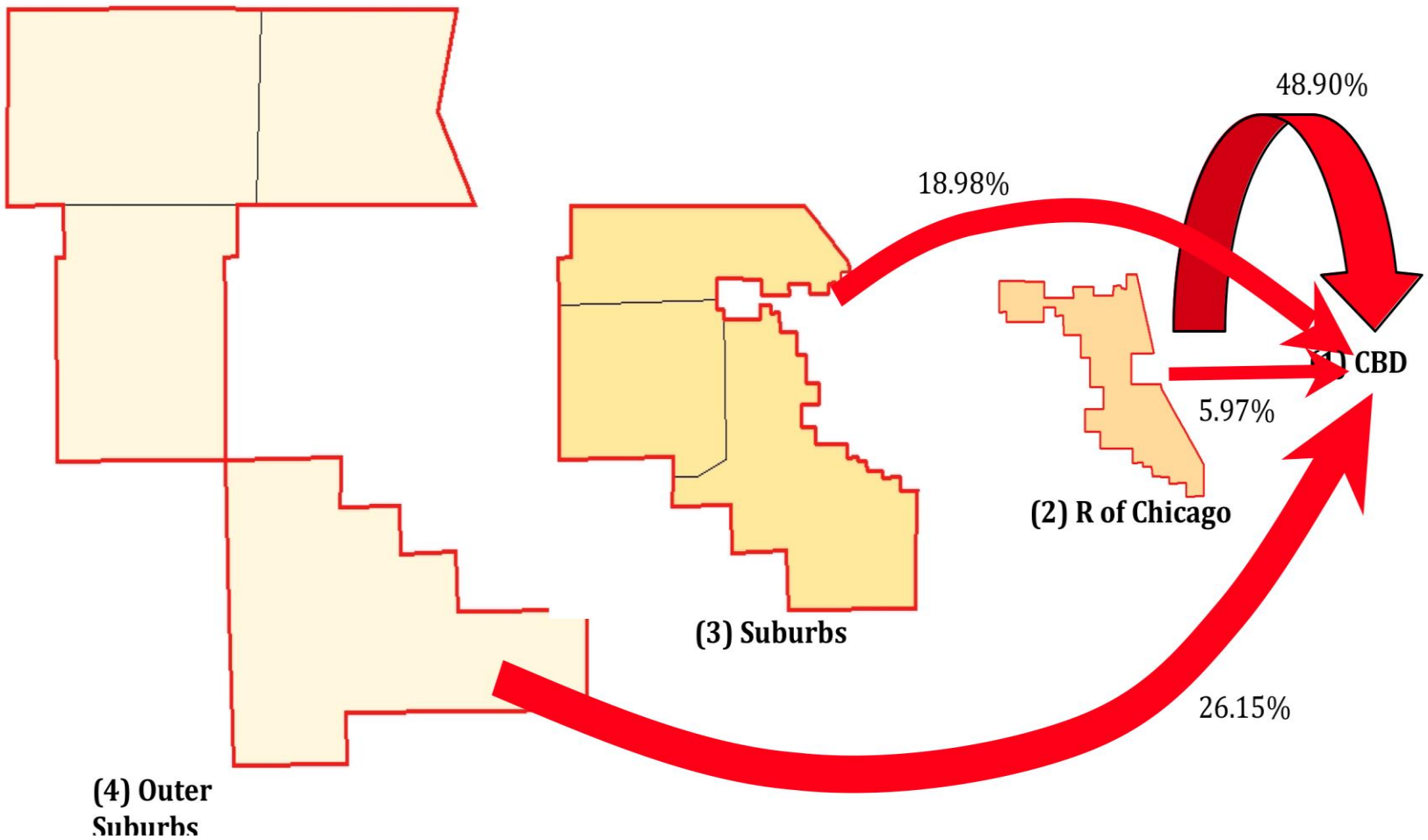


Total Spatial Interdependence

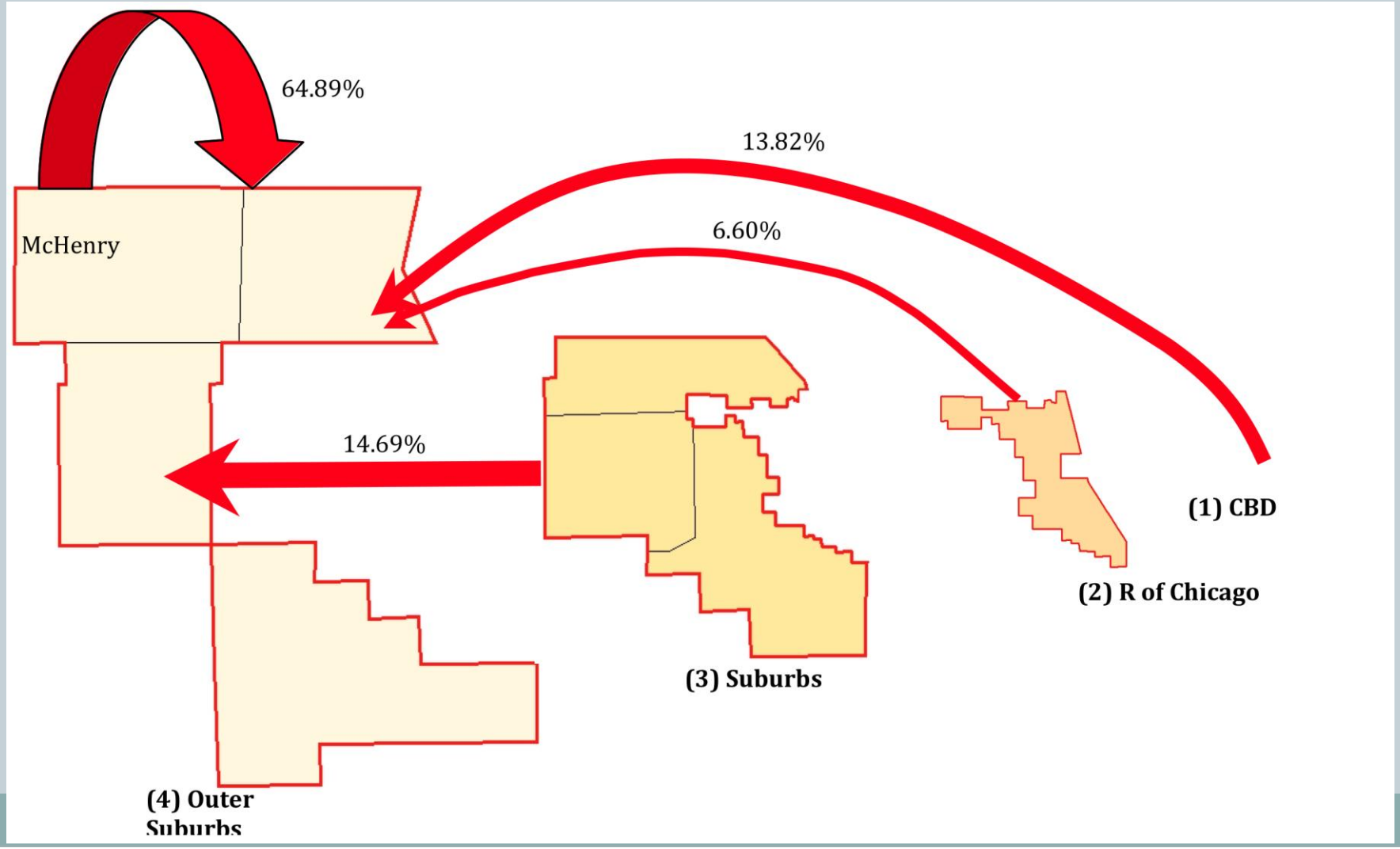
- Substantial interdependence when all interactions considered



Interzonal Impacts as Percentage of Total Impacts: CBD



Interzonal Impacts as Percentage of Total Impacts: Outer Suburbs



Changes in the Nature of Dependence as Complication Increases

- **Layer 1**
  - Intrazonal flows dominate the production relationships in the assembly of $479 billion worth of goods and services.
  - Somewhere between 90% and 94% of the direct and indirect effects of trade remain within the zone
- **Layer 4**
  - With the exception of zone 4, less than 50% of the total production impacts can be traced, directly and indirectly, to activity that is generated within the zone
  - Almost 14% of the impact in zone 4 (outer suburbs) can be traced to zone 1 (the central area or CBD) with a further 6% traced to zone 2 (rest of the City of Chicago)
- About 45-48% of the total impacts derived from income-consumption impacts

Unexpected Result: The Miyazawa Interrelational Income Multiplier

Miyazawa's Interrelational Income Multipliers				
	region of income origin			
	Region 1	Region 2	Region 3	Region 4
Region 1	1.23	**0.12**	0.16	0.07
Region 2	0.11	**1.28**	0.13	0.05
Region 3	0.03	**0.03**	1.06	0.01
Region 4	0.44	**0.56**	0.50	1.77
Total	1.81	**1.99**	1.85	1.90

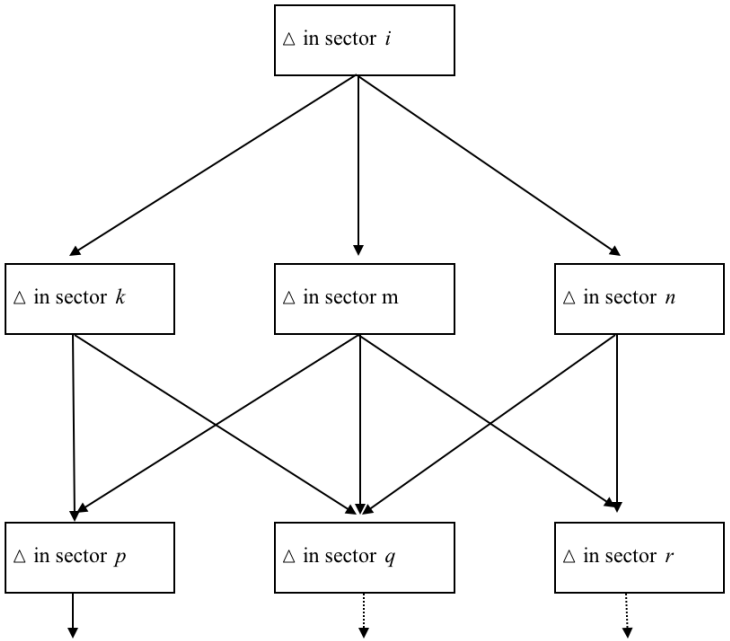
- Region 2 – **least prosperous but generated largest income multiplier (theory suggests that *apc* higher for lower income households)**
- Significant asymmetric spillovers – **suburbs benefit more from income growth in other regions than vice versa**

Horizontal and Vertical Multipliers

- Persky and Felsenstein introduced the notion of **vertical and horizontal multipliers** operating in urban labor markets
- Previous discussion has looked at the vertical (interindustry and extended) multipliers
- The labor market is also characterized by a process of job chaining that works in a similar fashion
- New job creation or vacancies that are filled result in a ripple effect in the labor market that has important implications for the functioning of the urban economy as a whole

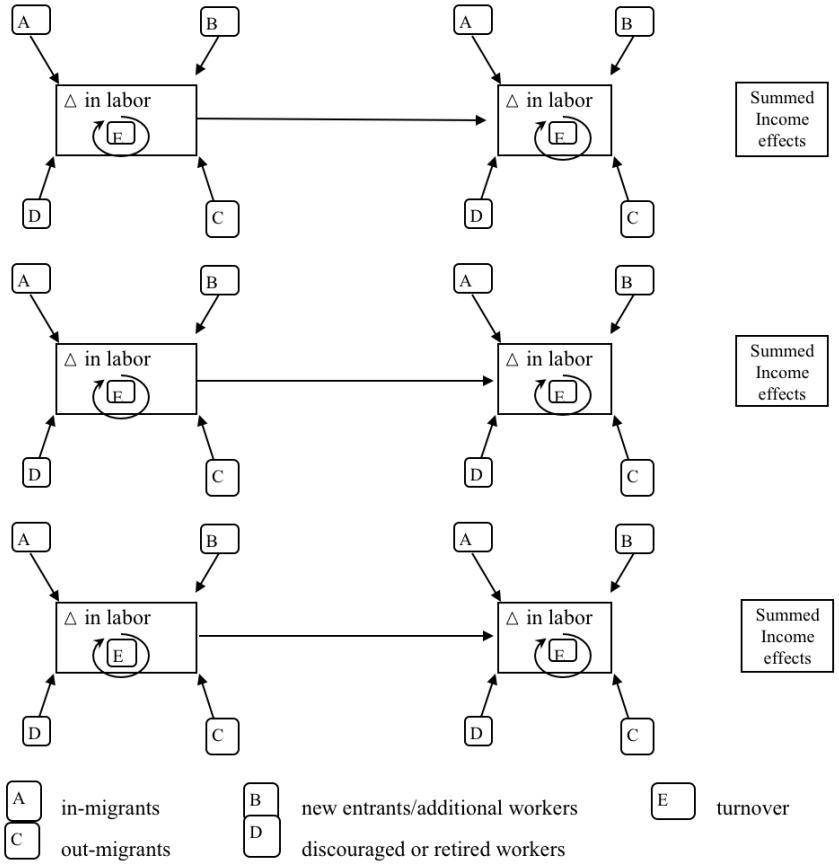
Horizontal and Vertical Multipliers

Interindustry Multiplier Effects



Job Chaining Effects

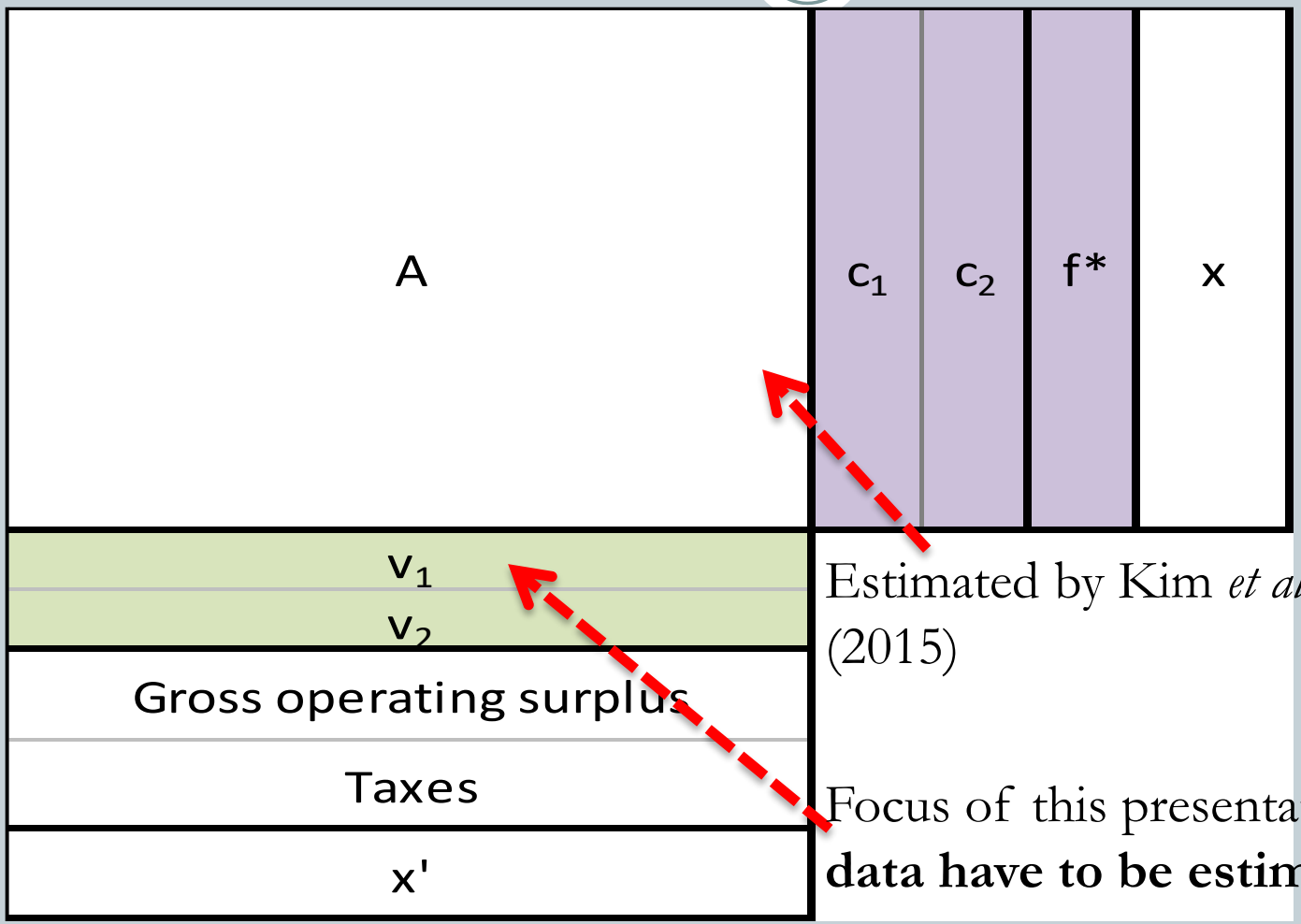
Length of chain will vary



Prior Work

- Prior work focused on the spatial disaggregation of income flows within a four- and twelve-fold division of the Chicago Metropolitan region
- However, only used a "representative household" in each region
- Current presentation describes methodology to disaggregate income received by households disaggregated by age and income
- Results incorporated into an econometric input-output model of the region

Endogenising Households



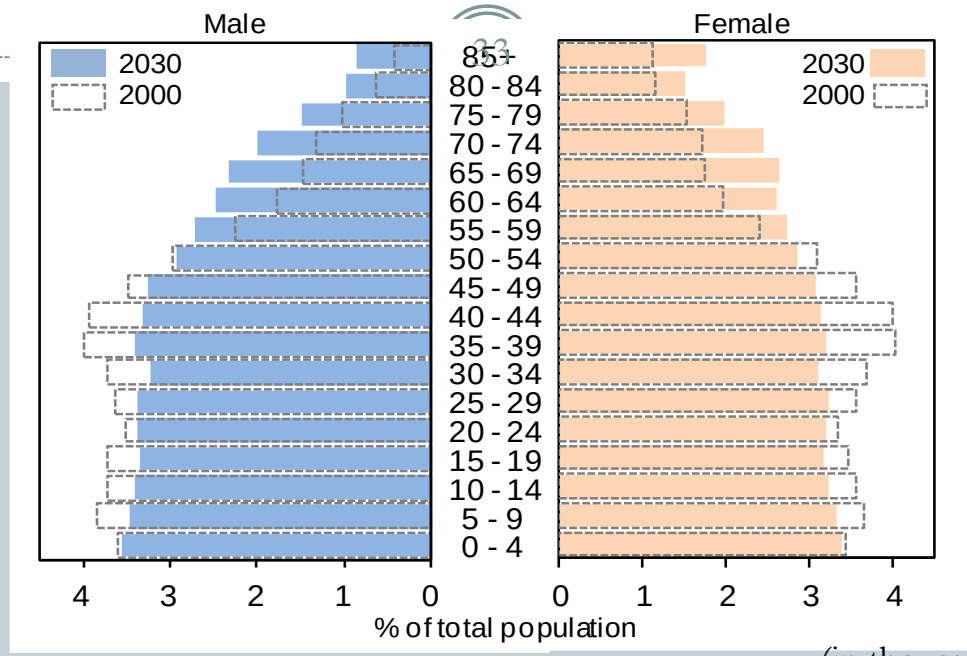
Background

- Income equality in the US has been deteriorating over the past several decades in large part due to:
  - **declining middle-income family shares** and, as Piketty reminds,
  - **the increase in the share of non wage and salary income** in total income.
- Supply-side proponents claim that lower taxes on the rich will lead to significant income gains to lower income households – the so-called "trickle-down effect" (see Krugman on the "trickle-up" effect of the Obama stimulus programs)
- Despite the growing global- and nation-wide concerns about deepening income inequality, the same issue at the sub-national level has not been investigated as comprehensively as at higher geographical levels – hundreds of papers but few explore the *system-wide implications*

Background (2)

- The regions of the US are expected to continue to experience dramatic changes in the composition of the labor force by age over the next a decade or so, resulting from aging population.
- It has become increasingly necessary to accompany some innovations in policies addressed to older workers such as the **provision of incentives to retain older workers longer in the labor market** (Munnell and Sass, 2008).
- Despite their small employment shares in the economy, older workers and younger workers have attracted attention from policy makers and labor economists.
- Specification of labor markets in regional models – Econometric-IO or CGE – is unsatisfactory; this paper is the first step in a major re-calibration that will include, *inter alia*, in and out-migration by skill/experience

Population in Illinois



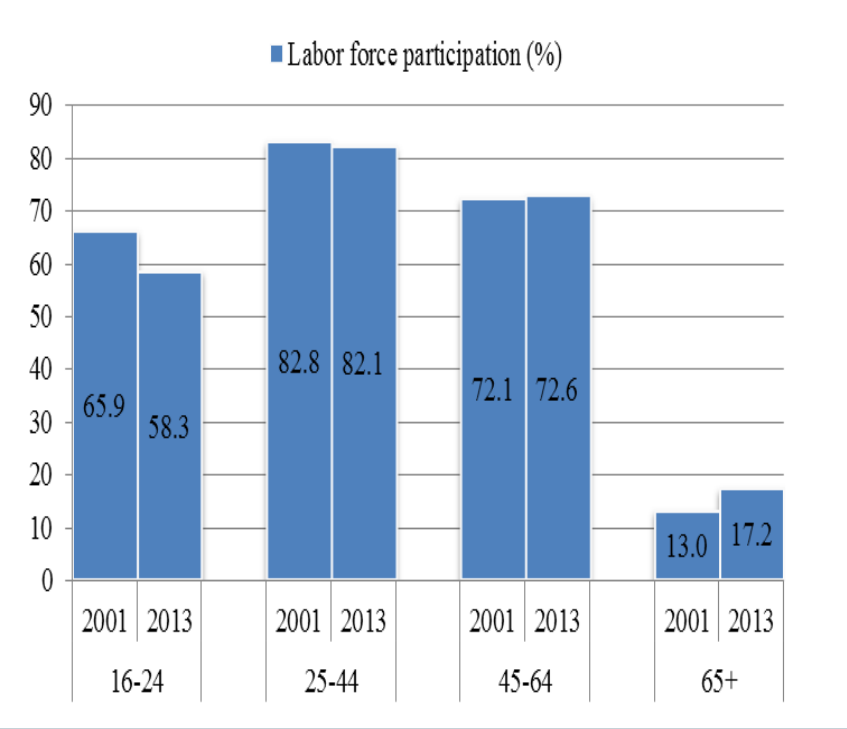
(in thousands)

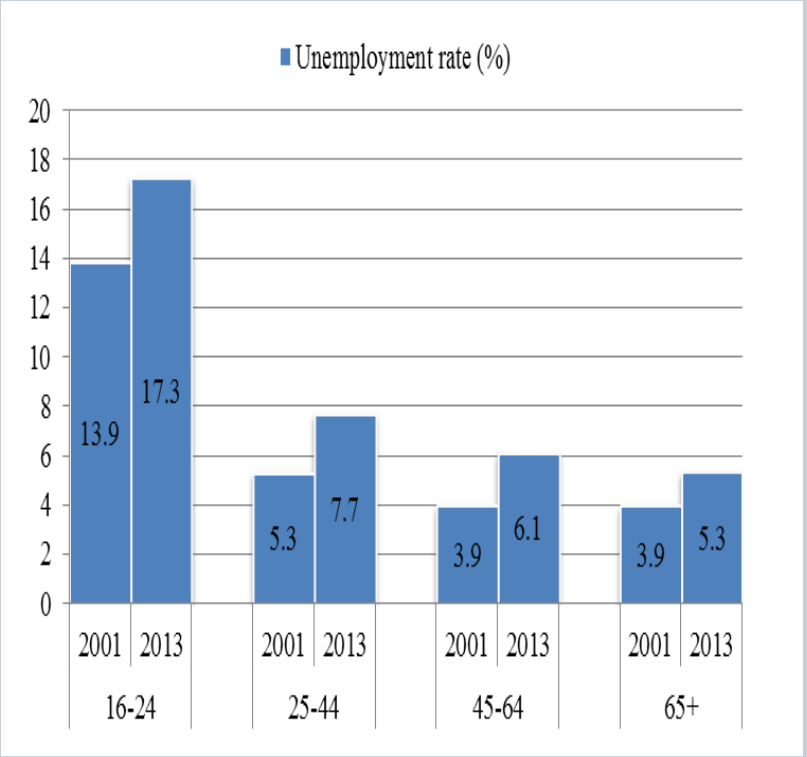
Cohort	2000	2030	Δ	%Δ
Total	12,419 (100)	13,433 (100)	1,014	8.16
Under 18	3,245 (26.1)	3,259 (24.3)	14	0.4
5-17	2,369 (19.1)	2,327 (17.3)	-42	-1.8
18-24	1,211 (09.8)	1,228 (09.1)	17	1.4
25-44	3,796 (30.6)	3,493 (26.0)	-303	-8.0
45-64	2,667 (21.5)	3,040 (22.6)	373	14.0
65+	1,500 (12.1)	2,412 (18.0)	912	60.8

Source: Population projections by the Census Bureau

Stylized facts

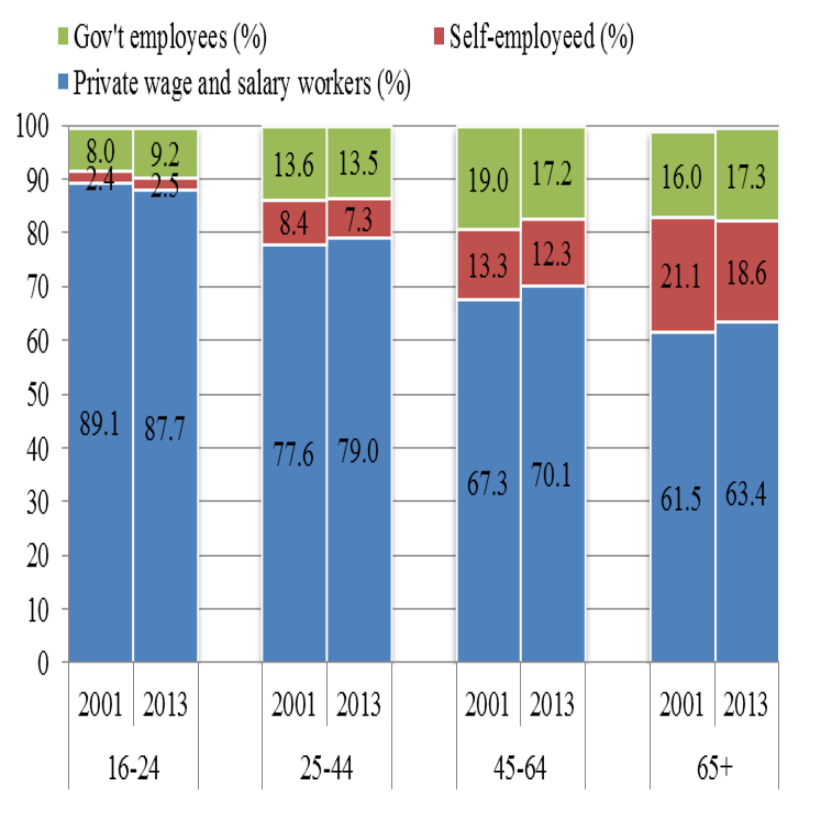
Labor participation and unemployment

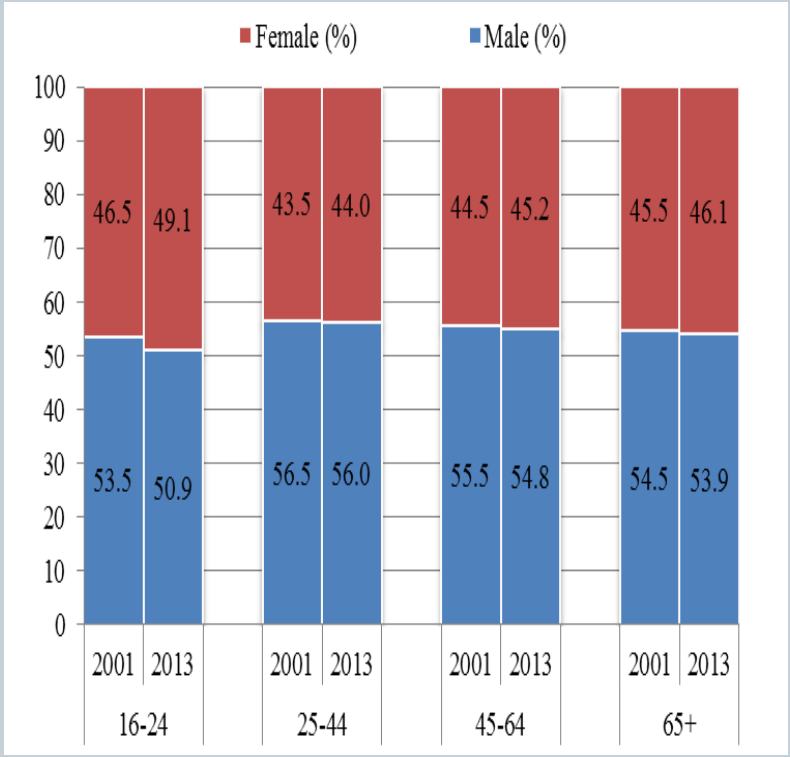




Stylized facts

Class of labor and sex

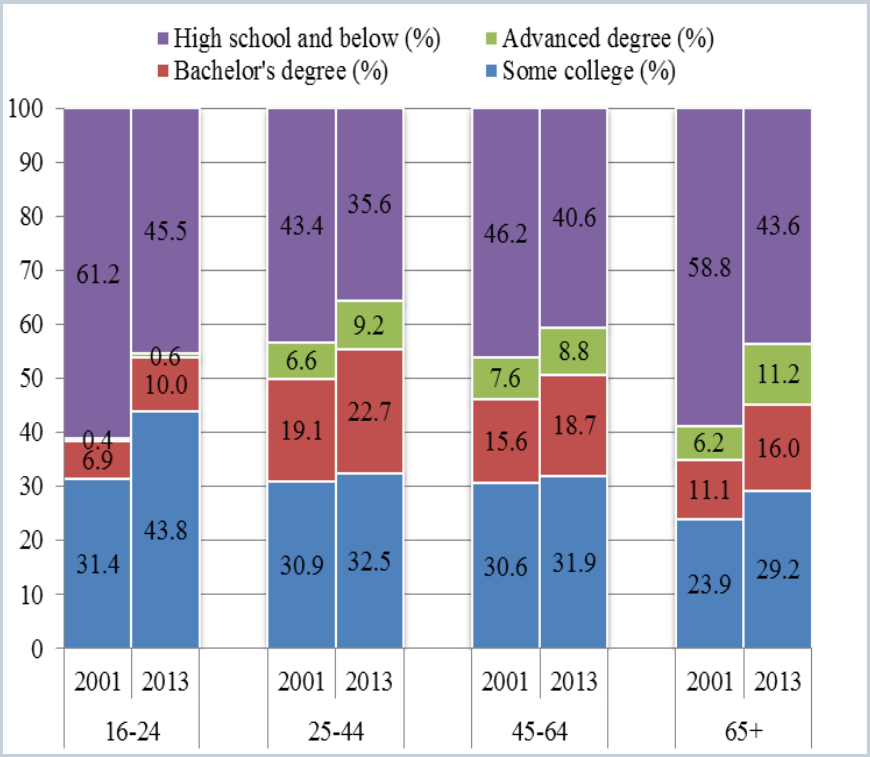




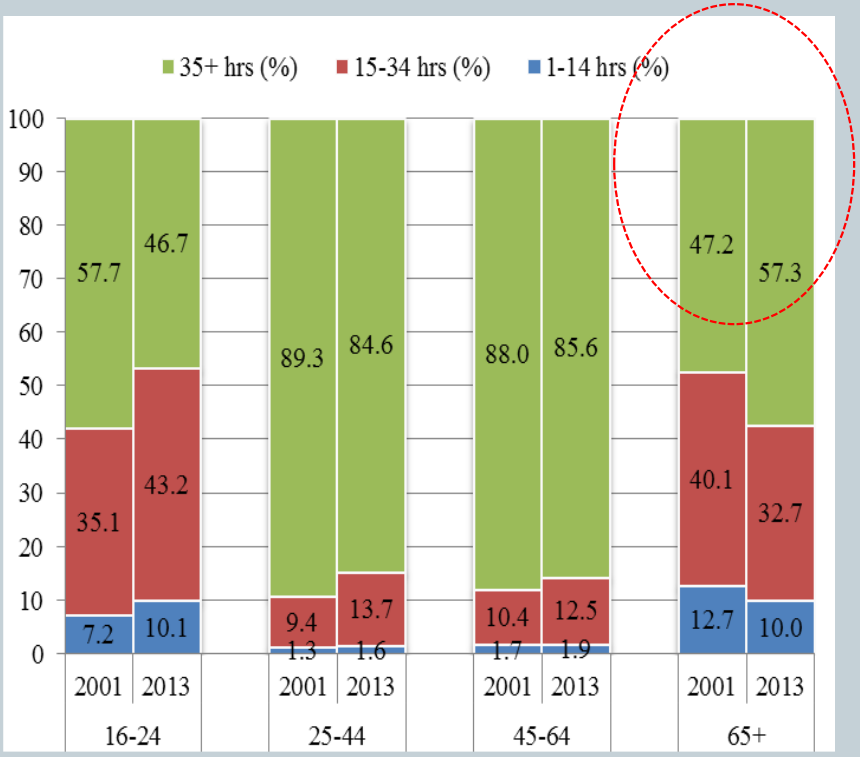
* Among private wage and salary workers

Stylized facts

Education attainment and hours of work*



* Among private wage and salary workers



* Among private wage and salary workers

Research questions

- How does labor demand vary by workers' age and across a set of disaggregated industry sectors? Also, labor-labor substitutions?
- How can we model long-run labor demand empirically?
- What can be analyzed with the labor demand model?
  - Response of employment to relative wage changes among age group workers
  - Effects of age distribution changes on regional economies (Chicago)
- What are policy implications associated with labor demand by age?
- For the geographical disaggregation we had matching income and consumption data; for this exercise, only has consumption and thus had to estimate income by household group (age or income)

Contributions

- The presentation is one of the few studies that measures labor demand for workers after retirement age (65+).
- More theoretically and empirically consistent estimates of wage elasticities are produced due to a Bayesian approach.
- It offers a potential application for linking a model of heterogeneous labor larger macroeconomic models.
- Actual application of labor demand to an extended input-output framework proves useful.

Static Labor Demand Model and a Bayesian Estimation

Model

- A translog labor cost function

- Assuming weakly separability between labor and other factors and a CRTS production, a translog unit labor cost function can be specified as

$$\log(W_t^r) = \alpha_0 + \mu^r + \theta t + \sum_g \alpha_g \log(w_{g,t}^r) + \frac{1}{2}\sum_g \sum_h \beta_{gh} \log(w_{g,t}^r)\log(w_{h,t}^r) + \sum_g \gamma_g \left\{\log(w_{g,t}^r)\right\} t$$

where r = region; g= sector, h = age group; W= mean annual wage

- This specification implies the followings:
  - the unit labor cost function differs by sector,
  - and also by region by means of changing intercepts (the fixed cost of labor);
  - overall time trend approximates overall labor qualities over time.

Model: Labor cost share equations

- Applying Shepherd's lemma to the cost function yields

$$s_{g,t}^{r} = \frac{\partial \log(W_t^r)}{\partial \log(w_{g,t}^r)} = \alpha_g + \sum_h \beta_{gh} \log(w_{g,t}^r) + \gamma_g t, \quad g = 1, \ldots, G$$

- This specification implies the following:
  - the time trend represents *group-specific* characteristics such as rising or falling input share due to demographic changes, holding the wage fixed.
- With homogeneity and symmetry imposed, iterated SUR is used to estimate *simultaneously* the translog unit labor cost function and the system of labor share equations.

Regularity conditions: Monotonicity in input prices

- Monotonicity requires non-negative labor cost shares because

$$\frac{\partial c_{L,t}}{\partial w^r_{g,t}} = \frac{c_{L,t}}{w_{g,t}} \frac{\partial \log c_{L,t}}{\partial \log(w^r_{g,t})} = \frac{c_{L,t}}{w_{g,t}} \left(\alpha_g + \sum_h \beta_{gh} \log(w^r_{g,t}) + \gamma_g t \right) > 0$$

- Monotonicity is more likely to be violated when shares for one or more factors are very small and negative signs of estimated cost shares will lead to seriously biased elasticity estimates.

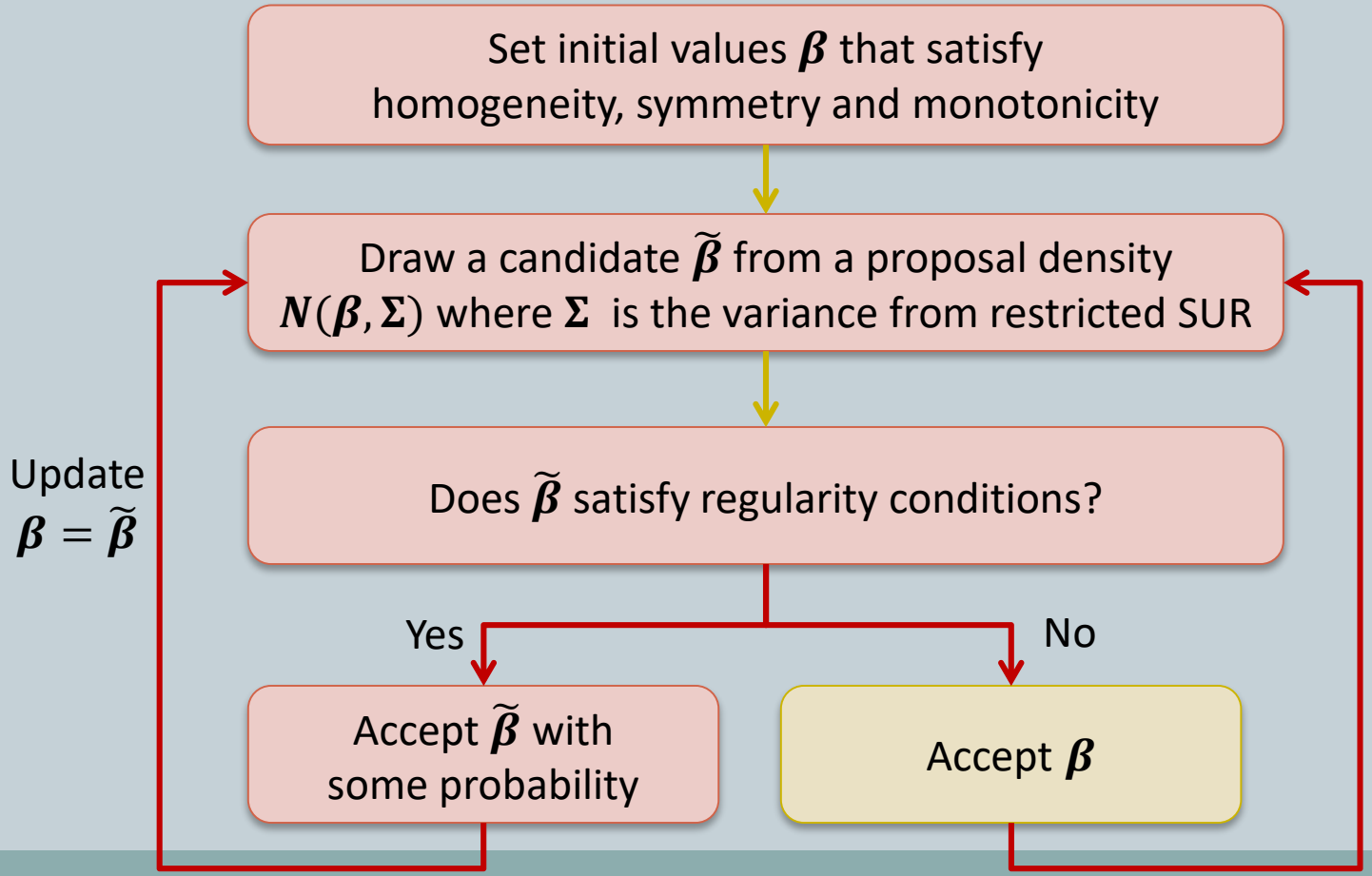
- Many empirical studies often fail to make the validity check of these conditions or proceeded without referring to regularity conditions (O'Donnell and Coelli, 2005).

Monotonicity: A Bayesian approach

- Since monotonicity and concavity require to be imposed at each data point, traditional econometric approaches are difficult to be implemented.
- A Bayesian approach facilitates the imposition of monotonicity and concavity due to its intuitive sampling nature while linear programming can be used for linear inequality constrains like monotonicity, but is not implementable to non-linear inequality constraints like concavity (O'Donnell and Coelli, 2005).
- Constrained maximization of the likelihood function is rather complex and the algorithms used for the optimization frequently have convergence problems (Henningsen and Henning, 2009).
- Following Griffiths *et al.* (2000), we use the Metropolis-Hastings algorithm to impose monotonicity for all data points, along with homogeneity and symmetry.

Metropolis-Hastings algorithm

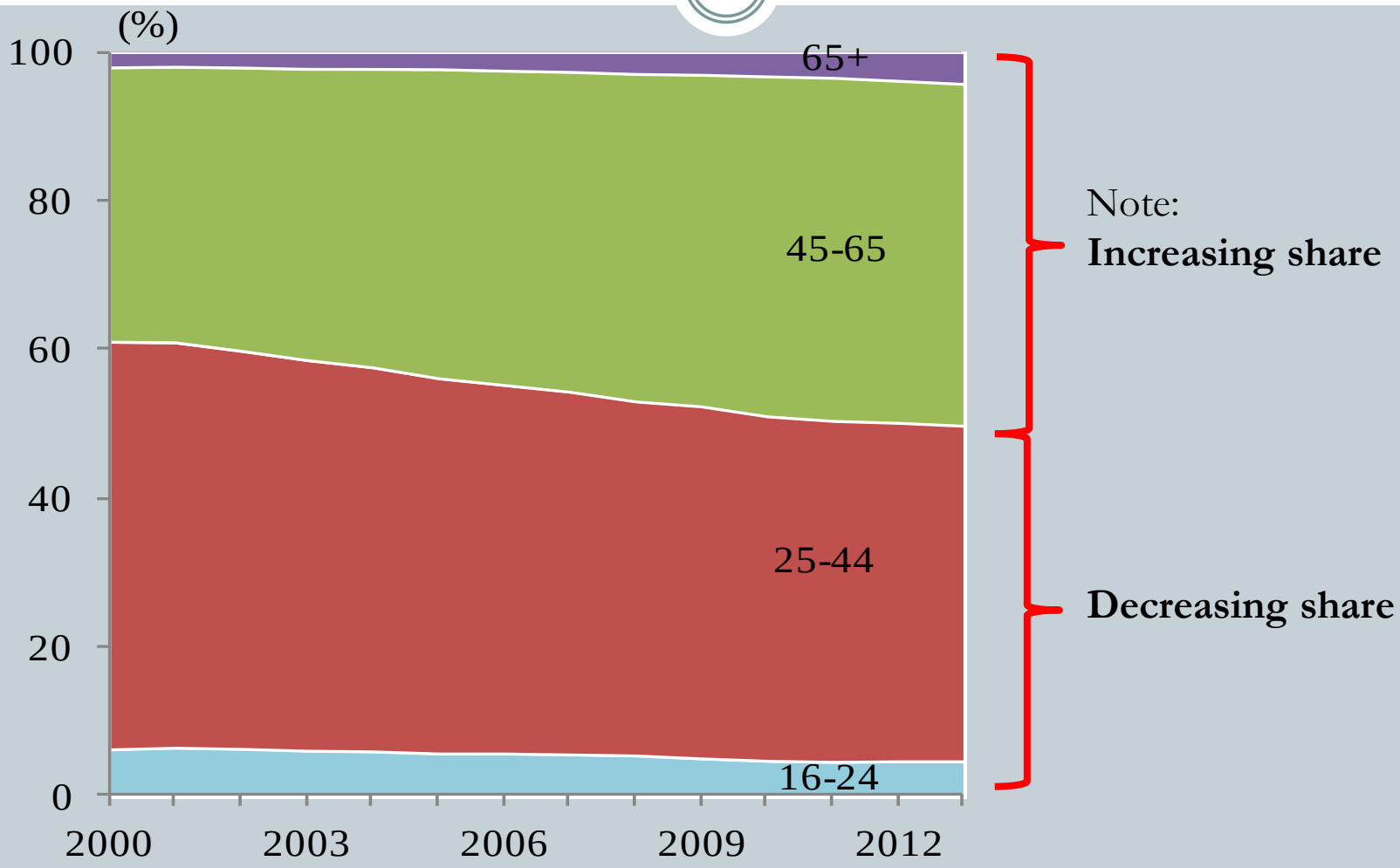
Objective: Draw samples from a *target* posterior distribution $f(\boldsymbol{\beta}|\boldsymbol{y})$
A *proposal* density is the distribution that a candidate is actually drawn from. In Markov chain theory, the samples generated from the proposal density follows the target distribution.



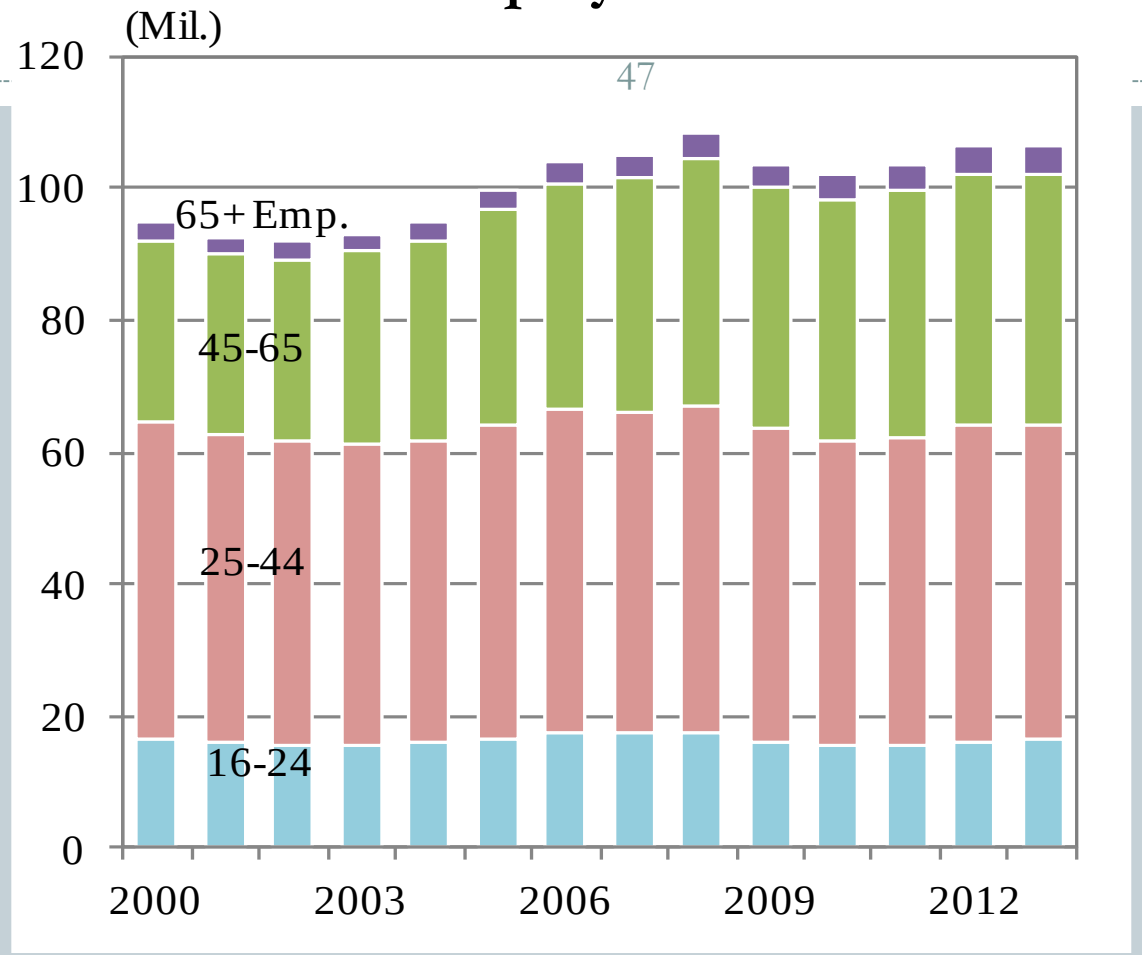
Data

- The American Community Survey (ACS) Public Use Microdata (PUMS)
- Based on the 2000-2013 ACS PUMS, the number of employees and mean annual wages and salary per employee are aggregated by state and by sector for 16-24, 25-44, 45-64 and 65+ age groups.
- *Private wage and salary workers* only
  - *Self*-employed workers, Armed Forces, state, local and federal government employees are excluded.

Labor cost (emp. x wage) shares

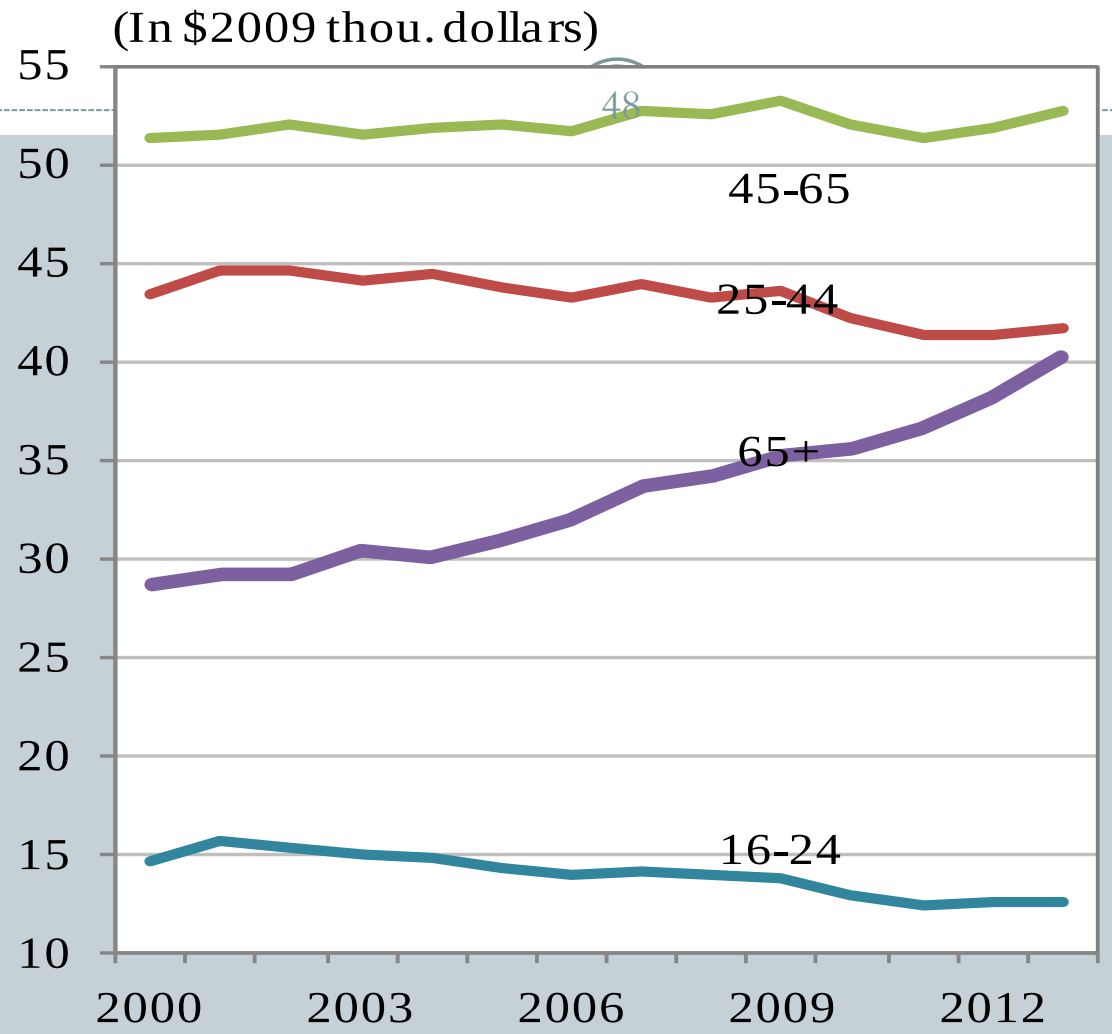


Employment*



* Self-employed, Armed Forces and government employees are excluded.
Source: Own calculations based on the 2000-2013 ACS

Annual wage and salary*



* Self-employed, Armed Forces and government employees are excluded.

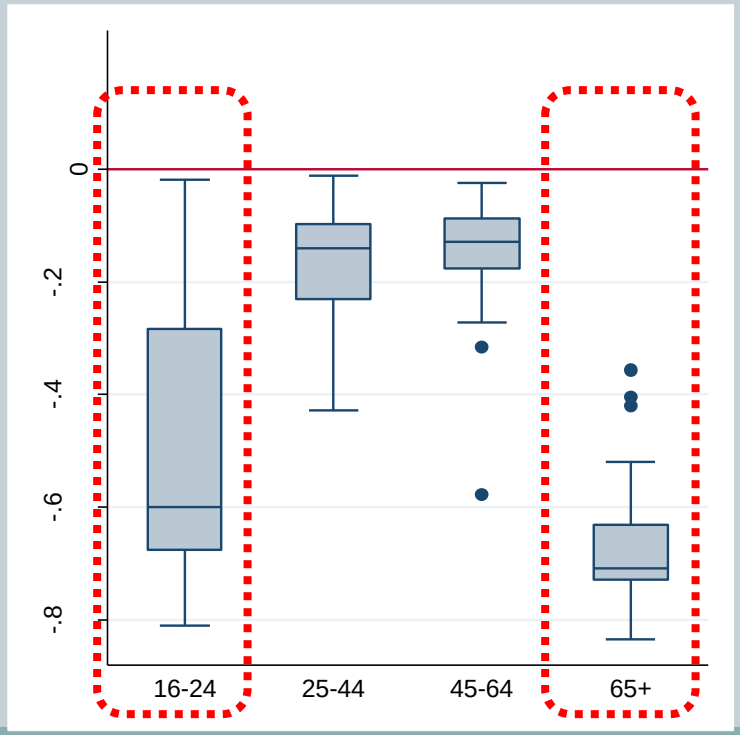
Source: Own calculations based on the 2000-2013 ACS

Distributions of own-price elasticity of labor demand

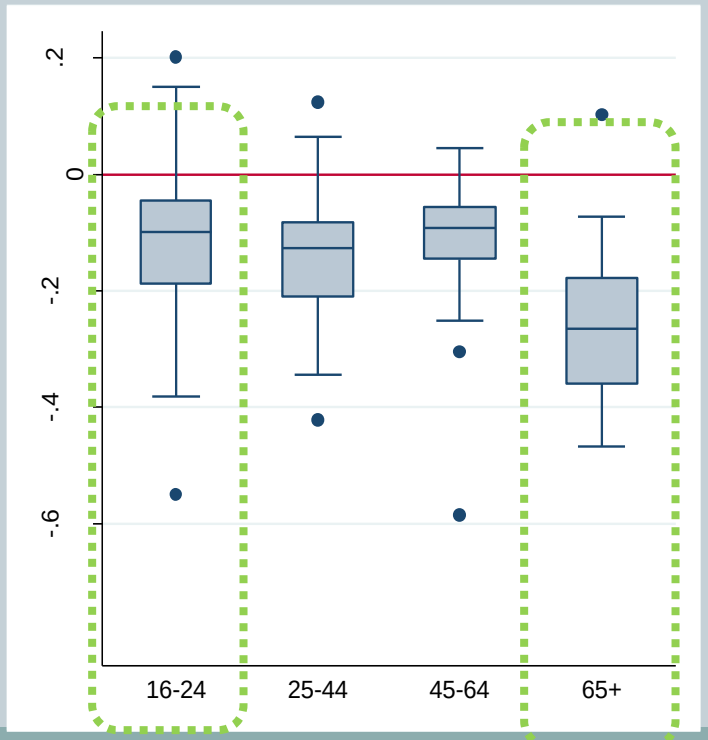
- 45 sectors evaluated at fitted mean shares

Labor demand elasticities for the youngest age-group vary widely by sector while labor demand for the oldest age-group is found to be consistently elastic with little variation across sector.

Bayesian SUR



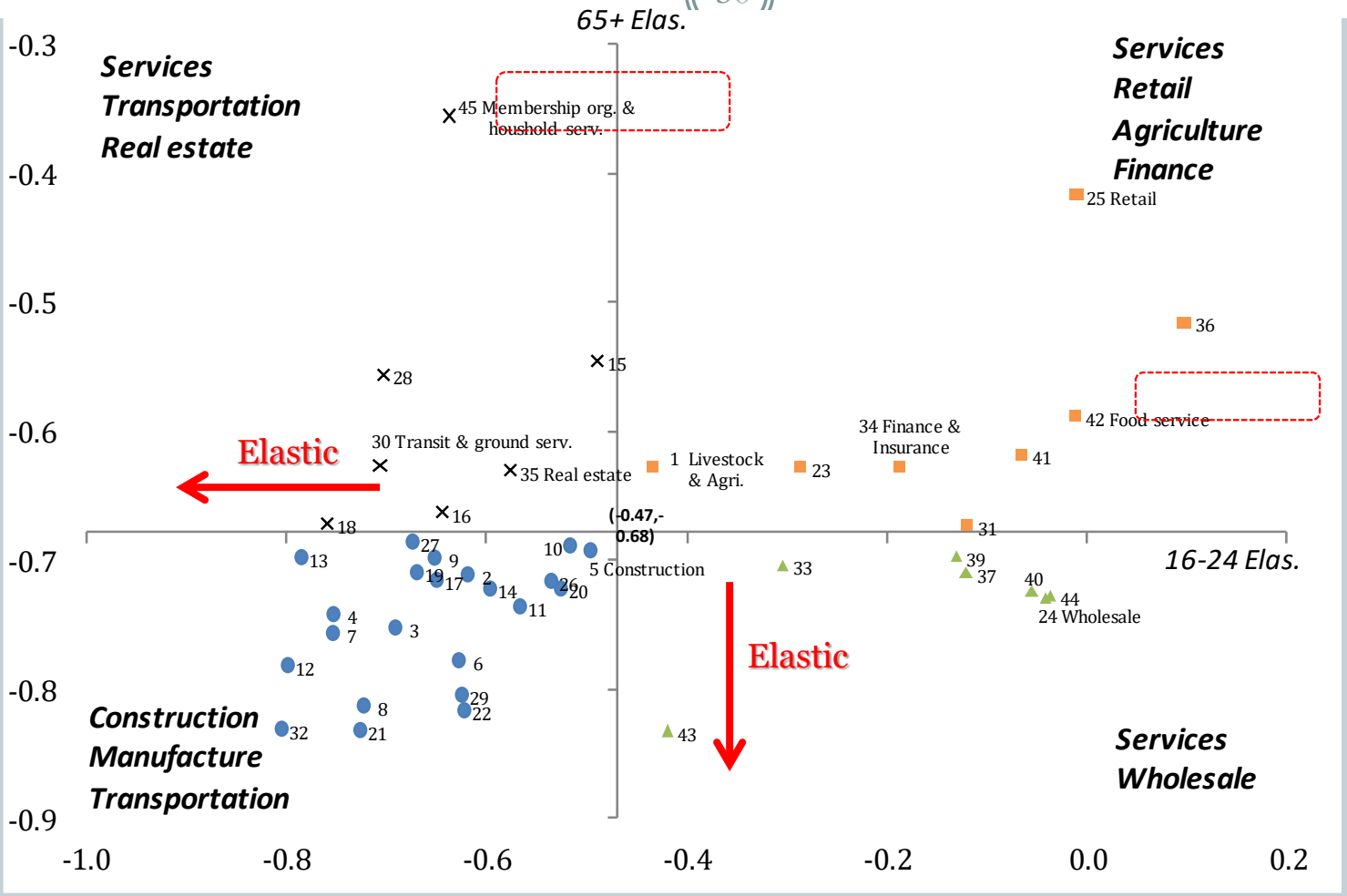
SUR



* Homogeneity, symmetry and monotonicity are imposed.

Own-price labor elasticities by sector for the youngest and oldest age-group employees :

(evaluated at fitted mean shares)

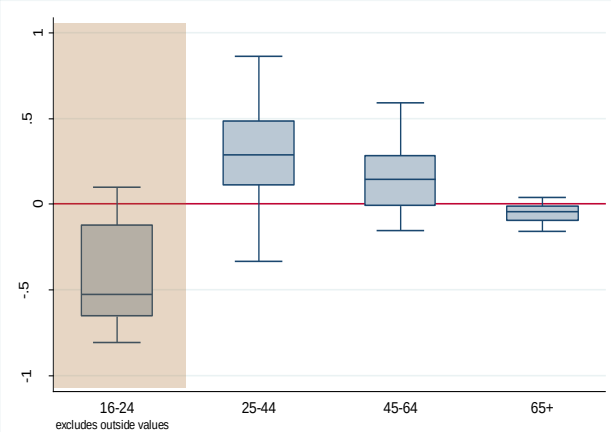


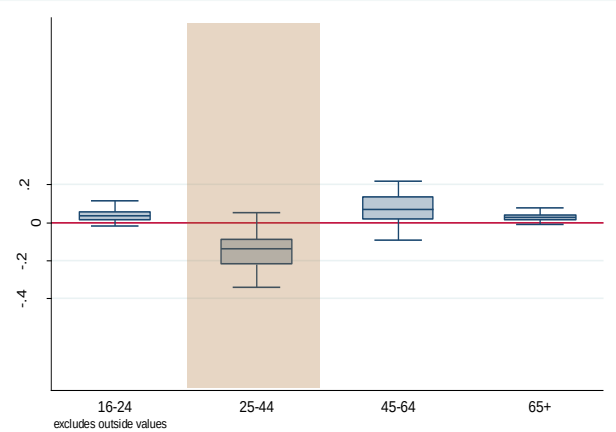
Notes: 1) The origin represents mean of elasticities; 2) The bold fonts represent aggregate sectors for those appearing most in the corresponding quadrants.

Distributions of cross-price elasticity of labor demand
- 45 sectors evaluated at fitted mean shares

Bayesian SUR

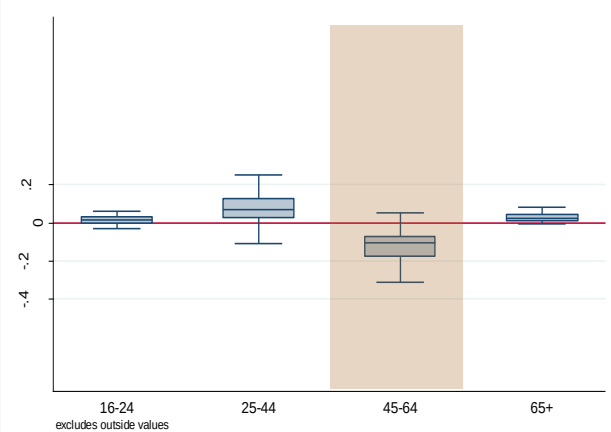
h_{1h}

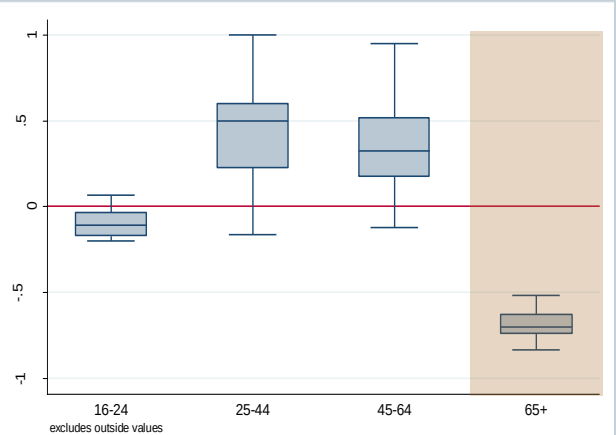




h_{2h}

h_{3h}



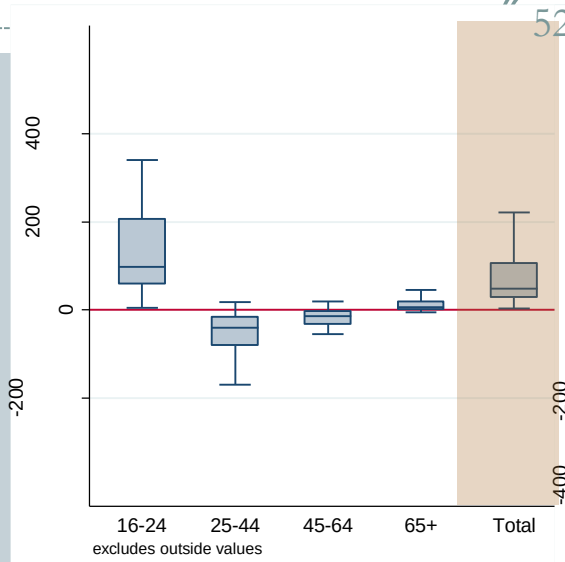


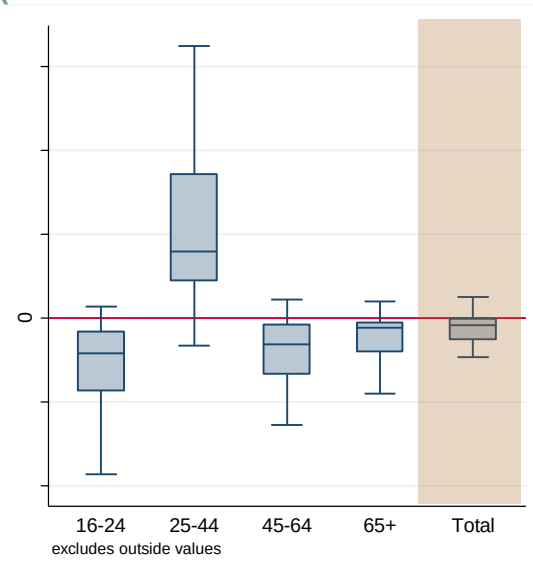
h_{4h}

* Homogeneity, symmetry and monotonicity are imposed.

Distributions of employment change per sector for 45 industries due to wage decline by 10 %

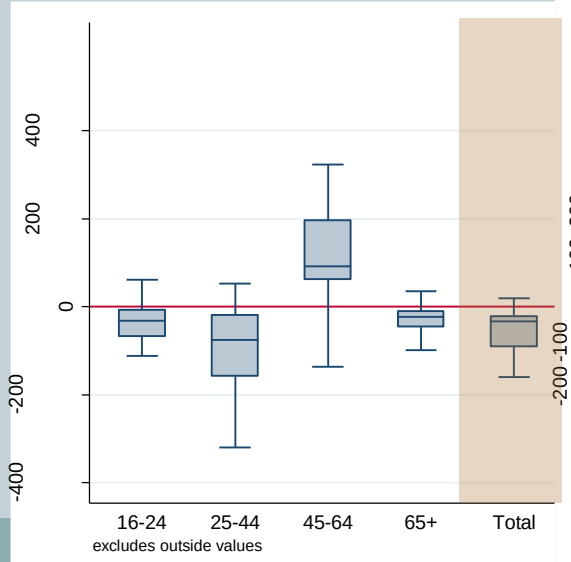
Wage change of 16-24 Age group

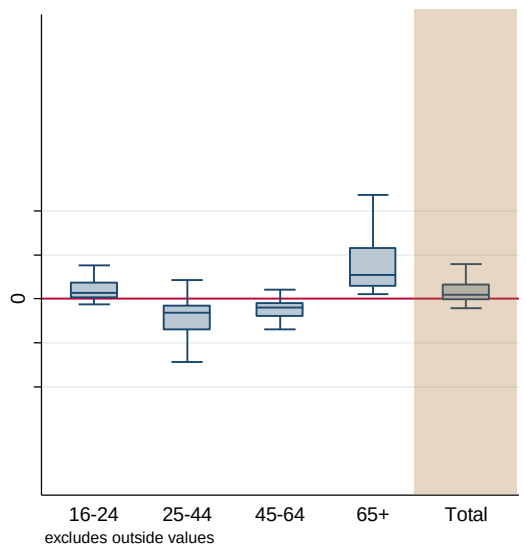




Wage change of 25-44 Age group

Wage change of 45-64 Age group

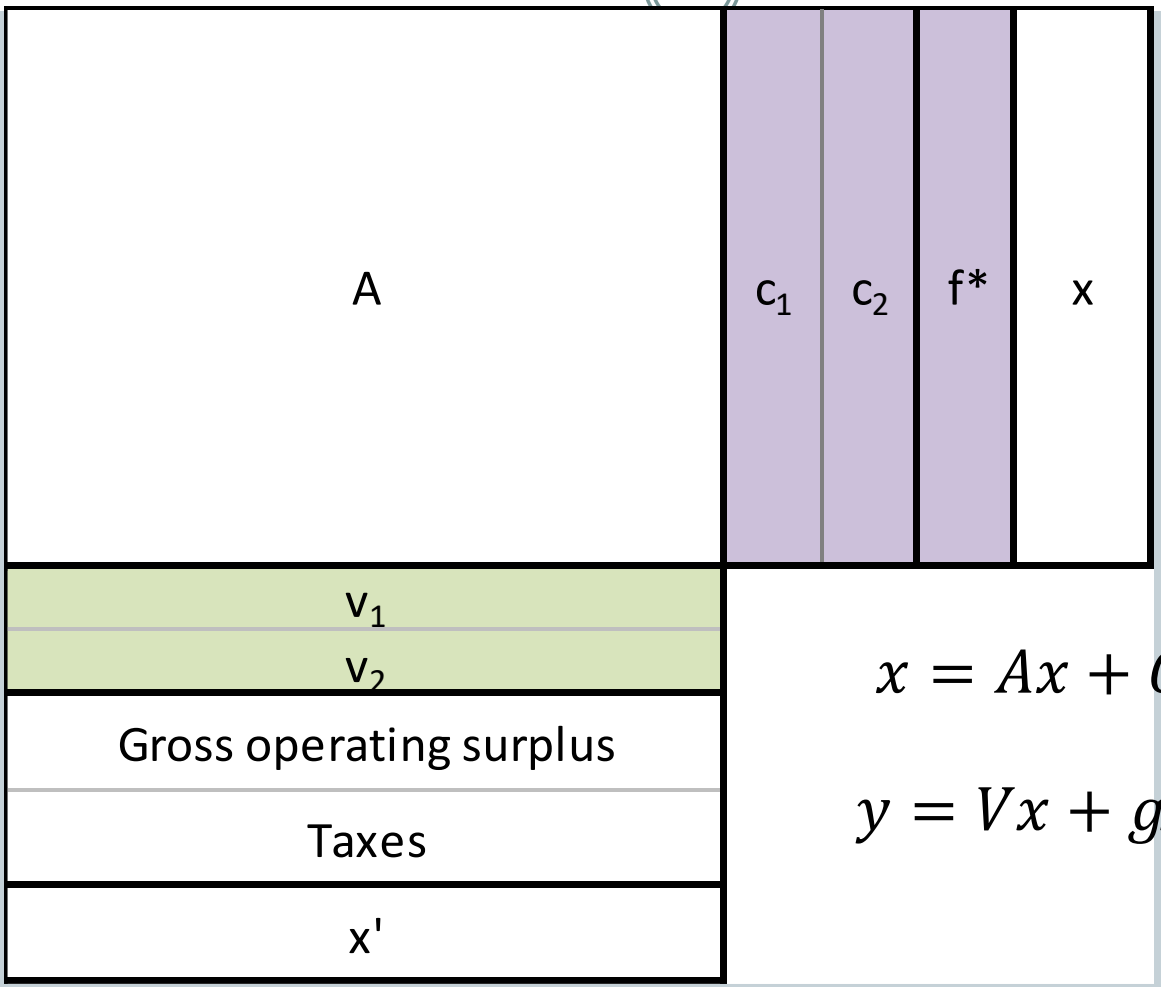




Wage change of 65+ Age group

Application to Miyazawa input-output framework

Schematic representation of Miyazawa model



$$x = Ax + Cy + f^*$$

$$y = Vx + gx + f$$

Miyazawa's extended input-output framework

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} A & C \\ V & 0 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} f^* \\ g \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} B(I + CKVB) & BCK \\ KVB & K \end{bmatrix} \begin{bmatrix} f^* \\ g \end{bmatrix}$$

where $\boldsymbol{V}$ = a matrix of labor income coefficients $\boldsymbol{C}$ = a matrix of consumption coefficients;

$\boldsymbol{f^*}$ = exogenous final demand;

g = exogenous income;

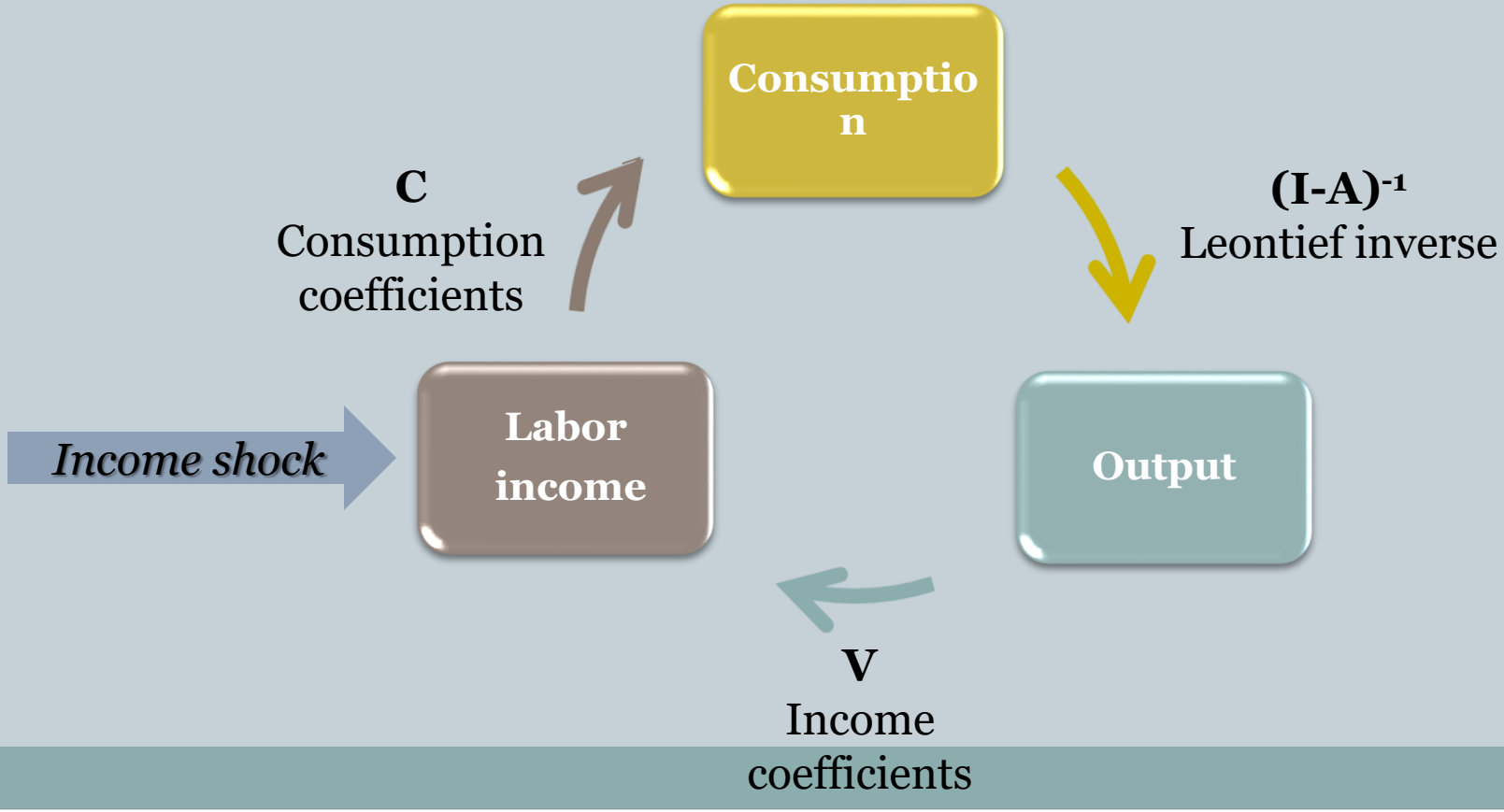
KVB are the *multi-sector income multipliers*

$$B = (I - A)^{-1};\ K = (I - L)^{-1};\ L = VBC$$

Interrelational income multipliers (*K* matrix)

$$K = \left[I - V(I - A)^{-1} C \right]^{-1} = (I - L)^{-1} = I + L + L^2 + \ldots$$

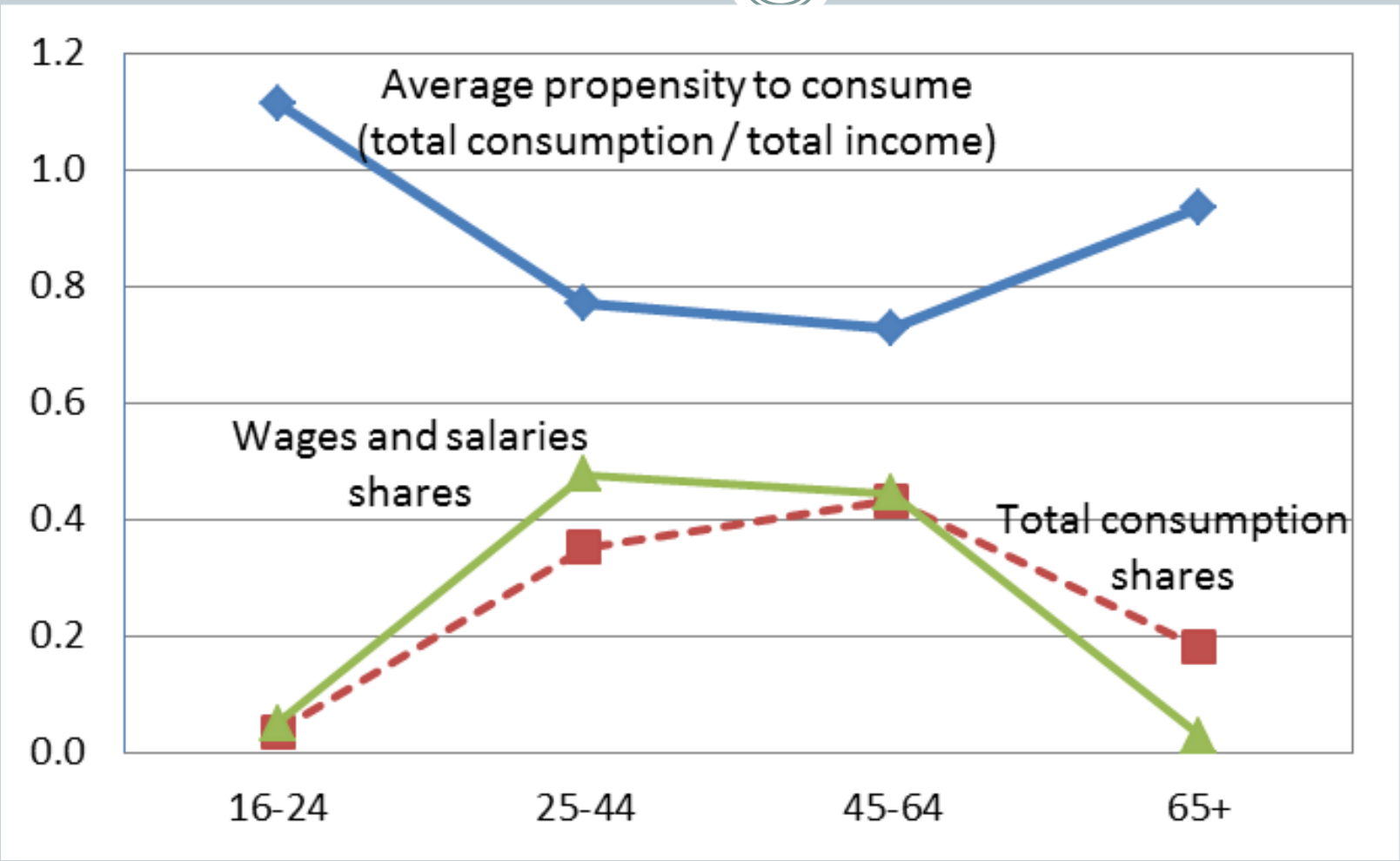
Indicates how a unit income increase in one group generates income in other groups

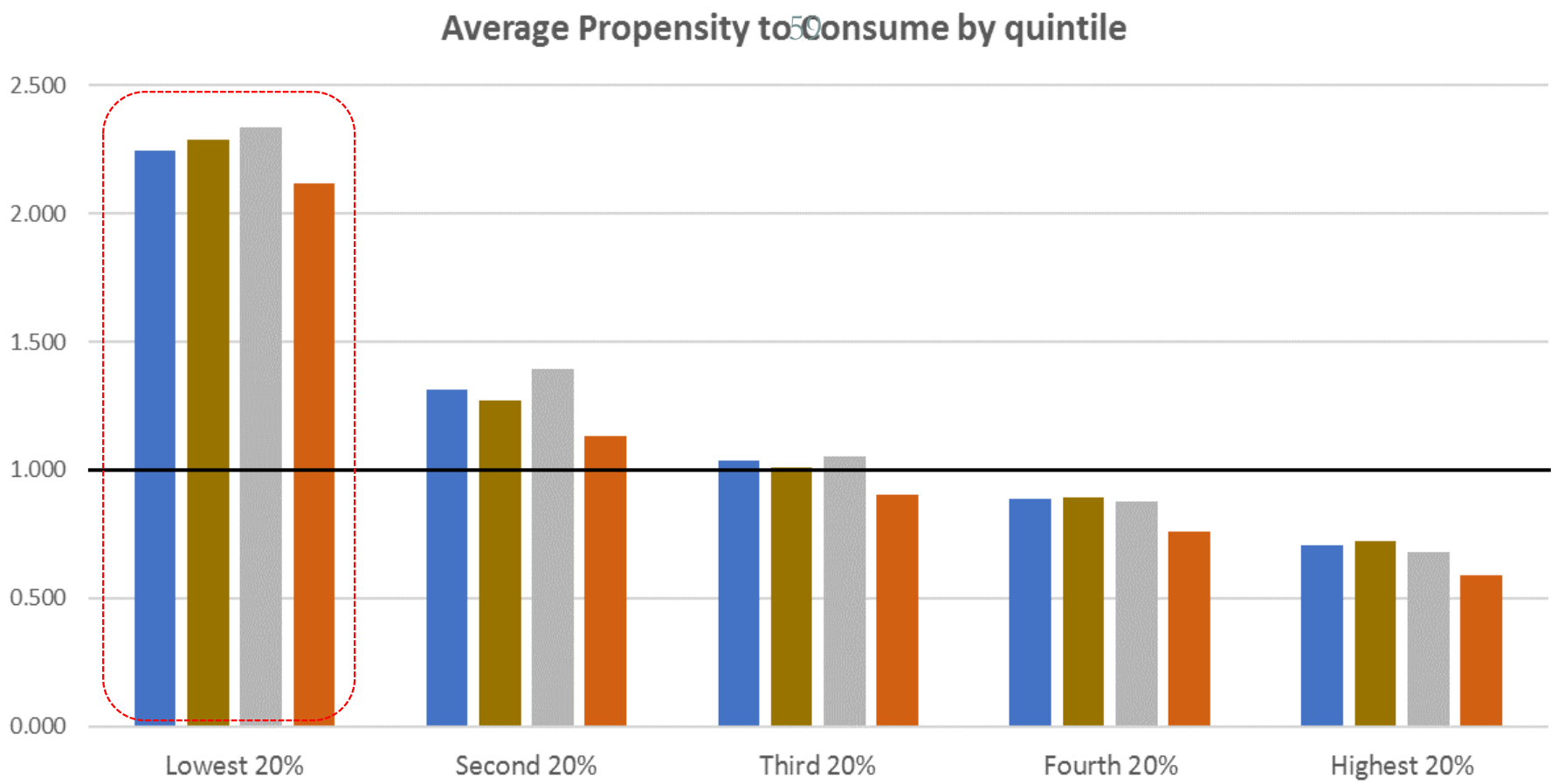


Data for Miyazawa framework

- An input-output table for Chicago with the base year of 2009 (the econometric IO model updates the table each year – see Israilevich *et al.*, *JRS*, 1997)
- Labor income coefficients matrix (V)
  - Estimated labor cost shares by age group for *Illinois* using the Bayesian SUR model
- Consumption coefficients matrix (C)
  - Estimated almost ideal demand system (AIDS) by age group (Kim, Kratena and Hewings, 2014) for Chicago
  - Average propensity to consume by age group: US Consumer Expenditure Survey

Consumption and income patterns by age group





Plus Hewings' sons and Eduardo Haddad's daughters apc >> 1.0!)

A Miyazawa analysis for Chicago: HH Disaggregation

- Main question:

  What are the effects of aging population on regional economic multipliers in Chicago? (only through changes in V and C)

- Assumptions:

1. Technology and relative prices of goods and labor groups do not change from the base year (2009) on.
2. Age distribution in the future is determined by the extended Chicago regional econometric input-output model (Kim, Kratena and Hewings, 2014).

The effects of changes in age distribution - Interrelational income multipliers (*K* matrix)

	Age group of income origin				
	16-24	25-44	45-64	65+	**Total**
Age group of income receipt: 2009					
16-24	1.055	0.037	0.035	0.045	**1.172**
25-44	0.423	1.292	0.286	0.383	**2.384**
45-64	0.378	0.263	1.259	0.349	**2.249**
65+	0.030	0.021	0.021	1.028	**1.100**
Total	**1.886**	**1.612**	**1.601**	**1.806**	**6.905**
Age group of income receipt: 2020					
16-24	1.043	0.028	0.027	0.035	**1.133**
25-44	0.362	1.249	0.244	0.326	**2.182**
45-64	0.440	0.304	1.299	0.404	**2.447**
65+	0.040	0.028	0.027	1.036	**1.131**
Total	**1.884**	**1.610**	**1.598**	**1.801**	**6.892**
Changes in indirect & induced impacts (%): 2020-2009					
16-24	-22.3	-22.7	-22.8	-22.7	**-22.6**
25-44	-14.4	-14.6	-14.6	-14.9	**-14.6**
45-64	16.3	15.7	15.5	15.5	**15.8**
65+	30.7	30.9	31.1	31.3	**31.0**
Total	**-0.25**	**-0.48**	**-0.55**	**-0.58**	**-0.45**

Average propensity to consume

Age composition of employment

Indirect effects "moving" from younger to older age groups over the period 2009-2020

The effects of changes in age distribution
- Multi-sector income multipliers (*KVB* matrix)

	Sector of final demand origin								
	Resource	Const.	Non-dur.	Dur.	TCU	Trade	FIRE	Services	**Total**
Age group of income receipt: 2009									
16-24	0.037	0.061	0.041	0.045	0.041	0.055	0.025	0.068	**0.373**
25-44	0.223	0.493	0.384	0.410	0.377	0.415	0.284	0.465	**3.052**
45-64	0.212	0.415	0.382	0.413	0.390	0.386	0.238	0.412	**2.850**
65+	0.016	0.029	0.029	0.029	0.027	0.030	0.018	0.036	**0.215**
Total	**0.489**	**0.998**	**0.836**	**0.897**	**0.836**	**0.886**	**0.566**	**0.981**	**6.489**
Age group of income receipt: 2020									
16-24	0.028	0.036	0.032	0.034	0.031	0.043	0.015	0.055	**0.275**
25-44	0.191	0.419	0.315	0.333	0.315	0.344	0.244	0.406	**2.566**
45-64	0.248	0.499	0.450	0.490	0.452	0.457	0.280	0.471	**3.346**
65+	0.019	0.037	0.037	0.038	0.035	0.039	0.024	0.047	**0.275**
Total	**0.486**	**0.991**	**0.833**	**0.894**	**0.833**	**0.883**	**0.563**	**0.978**	**6.462**
Changes in indirect & induced impacts (%): 2020-2009									
16-24	-23.3	-40.4	-21.7	-25.7	-24.2	-20.4	-39.8	-19.3	**-26.3**
25-44	-14.7	-15.1	-18.0	-18.9	-16.4	-17.1	-14.3	-12.7	**-15.9**
45-64	16.8	20.3	17.7	18.6	15.8	18.2	17.6	14.2	**17.4**
65+	18.9	27.4	27.2	30.9	27.1	29.0	35.3	27.9	**28.1**
Total	**-0.53**	**-0.71**	**-0.31**	**-0.36**	**-0.34**	**-0.34**	**-0.45**	**-0.33**	**-0.42**

Age composition of employment by sector

The effects of changes in age distribution - Output multipliers

	Sector of final demand origin								
Column sums of matrix	Resource	Const.	Nondur	Dur.	TCU	Trade	FIRE	Serv	**Average**
Type I: Direct & indirect (2009)	1.427	1.587	1.862	1.691	1.624	1.329	1.483	1.506	**1.563**
Type II: Direct, indirect & induced (2009)	2.001	2.752	2.832	2.732	2.593	2.364	2.139	2.657	**2.509**
Type II: Direct, indirect & induced (2020)	1.992	2.728	2.822	2.720	2.583	2.353	2.130	2.646	**2.497**
Changes in indirect & induced impacts (%): 2020-2009	**-0.86**	**-1.35**	**-0.52**	**-0.68**	**-0.63**	**-0.81**	**-0.77**	**-0.67**	**-0.78**

Changes reflect continuing hollowing out of the regional economy – sector dependence on local inputs and local markets declining
Households buying more goods and services from outside the region – e-commerce

Evolution of interrelational income multipliers in Chicago

Income group of income origin

Income group of income receipt

1980	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	1.18	0.11	0.08	0.07	0.06	1.49
Q2	0.88	1.52	0.41	0.35	0.28	3.45
Q3	1.55	0.92	1.73	0.62	0.49	5.31
Q4	2.31	1.37	1.08	1.93	0.73	7.42
Q5	3.51	2.08	1.65	1.41	2.12	10.78
Col. Sum	9.43	5.99	4.97	4.39	3.67	28.45

Income group of income origin

Income group of income receipt

1990	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	1.14	0.08	0.06	0.05	0.04	1.37
Q2	0.65	1.36	0.29	0.25	0.20	2.76
Q3	1.20	0.66	1.52	0.47	0.38	4.22
Q4	1.87	1.03	0.82	1.73	0.59	6.03
Q5	3.22	1.78	1.41	1.26	2.02	9.69
Col. Sum	8.08	4.91	4.09	3.77	3.23	24.07

Income group of income origin

Income group of income receipt

2000	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	1.24	0.14	0.11	0.09	0.07	1.65
Q2	0.94	1.57	0.43	0.36	0.28	3.56
Q3	1.65	1.00	1.75	0.63	0.49	5.52
Q4	2.61	1.58	1.19	1.99	0.77	8.13
Q5	4.89	2.96	2.24	1.87	2.45	14.42
Col. Sum	11.33	7.25	5.71	4.94	4.05	33.28

Income group of income origin

Income group of income receipt

2010	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	1.12	0.07	0.05	0.04	0.03	1.32
Q2	0.46	1.25	0.20	0.17	0.13	2.20
Q3	0.83	0.45	1.36	0.30	0.24	3.17
Q4	1.33	0.72	0.58	1.49	0.38	4.50
Q5	2.68	1.46	1.18	0.99	1.79	8.09
Col. Sum	6.42	3.93	3.36	2.99	2.57	19.28

Percentage changes in indirect impacts

1990-1980	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	-23.3	-28.6	-29.0	-25.6	-24.4	-25.8
Q2	-25.8	-30.8	-31.1	-27.9	-26.5	-28.1
Q3	-22.8	-28.1	-28.3	-25.0	-23.5	-25.2
Q4	-18.9	-24.5	-24.8	-21.3	-19.7	-21.5
Q5	-8.3	-14.5	-14.8	-10.8	-8.8	-11.1
Col. Sum	-16.0	-21.7	-22.0	-18.3	-16.6	-18.7

2000-1990	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	73.9	91.0	82.4	70.3	64.2	77.2
Q2	42.9	56.7	49.4	39.5	34.3	45.3
Q3	38.1	51.3	44.2	34.7	29.5	40.3
Q4	39.4	52.8	45.6	36.1	30.9	41.7
Q5	51.9	66.5	58.6	48.2	42.5	54.4
Col. Sum	45.9	59.9	52.3	42.3	36.9	48.2

2010-2000	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	-48.6	-54.4	-51.3	-51.1	-50.3	-50.9
Q2	-51.2	-56.6	-53.7	-53.4	-52.6	-53.3
Q3	-49.9	-55.3	-52.3	-52.0	-51.1	-51.9
Q4	-48.9	-54.4	-51.3	-50.9	-50.0	-50.9
Q5	-45.2	-50.9	-47.4	-46.9	-45.9	-47.1
Col. Sum	-47.5	-53.1	-49.8	-49.4	-48.4	-49.5

Focus of 2010 Interrelational Income Multipliers

2010	Q1	Q2	Q3	Q4	Q5	Row Sum
Q1	1.12	0.07	0.05	0.04	0.03	1.32
Q2	0.46	1.25	0.20	0.17	0.13	2.20
Q3	0.83	0.45	1.36	0.30	0.24	3.17
Q4	1.33	0.72	0.58	1.49	0.38	4.50
Q5	2.68	1.46	1.18	0.99	1.79	8.09
Col. Sum	6.42	3.93	3.36	2.99	2.57	19.28

2010	Q1	Q5
Q1	2.21%	1.91%
Q2	8.49%	8.28%
Q3	15.31%	15.29%
Q4	24.54%	24.20%
Q5	49.45%	50.32%

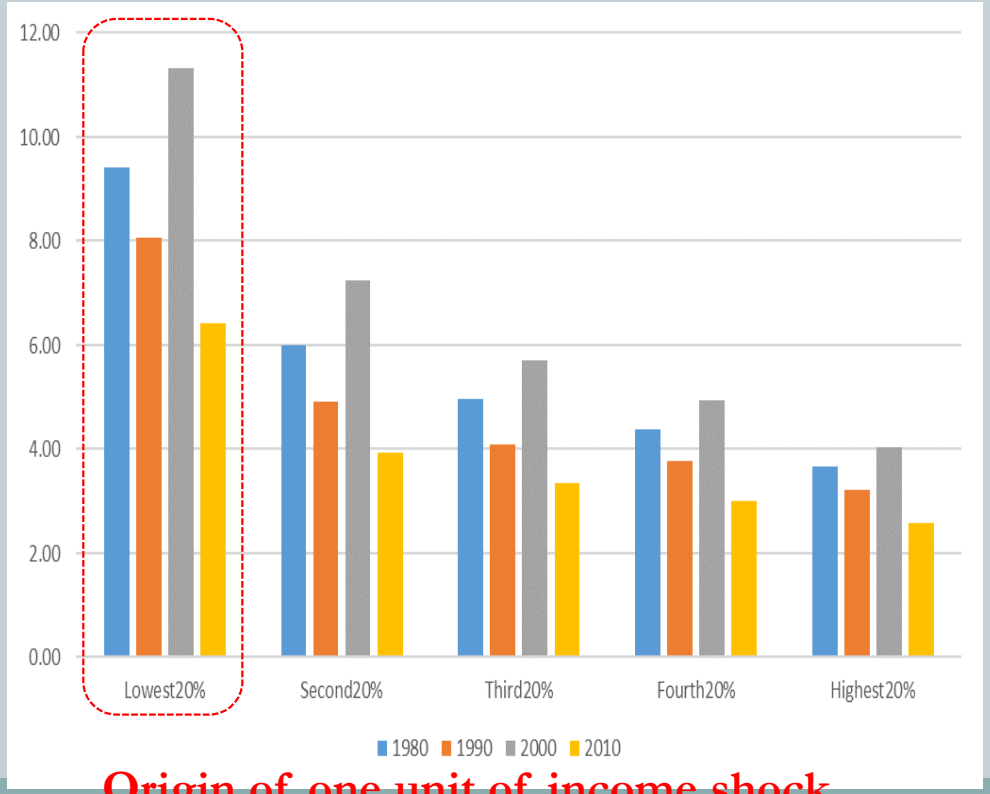
- The full matrix is shown on the left
- To highlight the asymmetry, the distribution of spillover effects is shown on the right
- **Lowest Income Group (1):**
  - Intra-group spillover very small (<3%)
  - Very large spillover to highest income groups (25% and 49%)
- **Highest Income Group (2):**
  - Intra-group spillover very large (>50%)
  - Very small spillover to lowest group (<2%)

Evolution of interrelational income multipliers in Chicago (2)

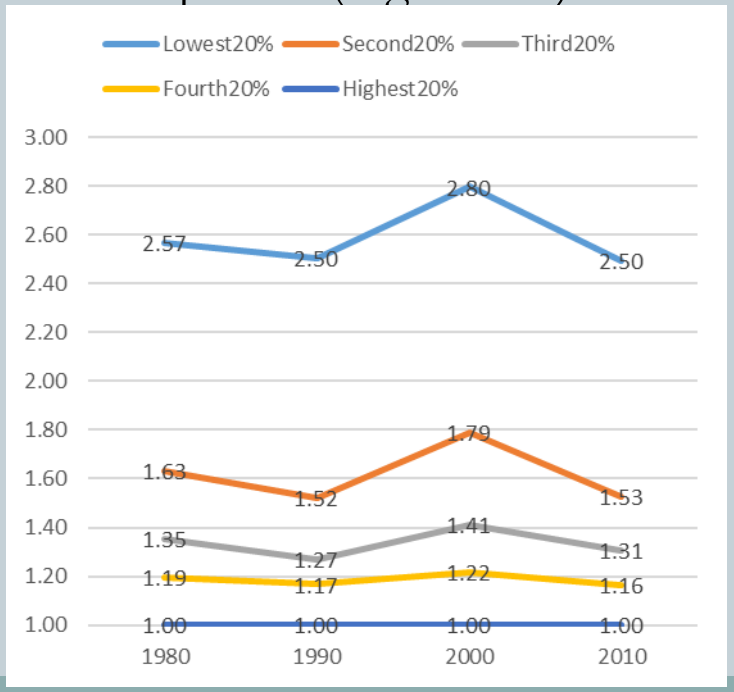
Economy-wide income impact is the largest when an income shock originates from the lowest 20 percent income group.

The lowest income group generate 2.5 to 3 times as high total income as the highest income group does.

Total income generated by income origin quintile



Ratios of total income generated by income origin quintile (highest=1)



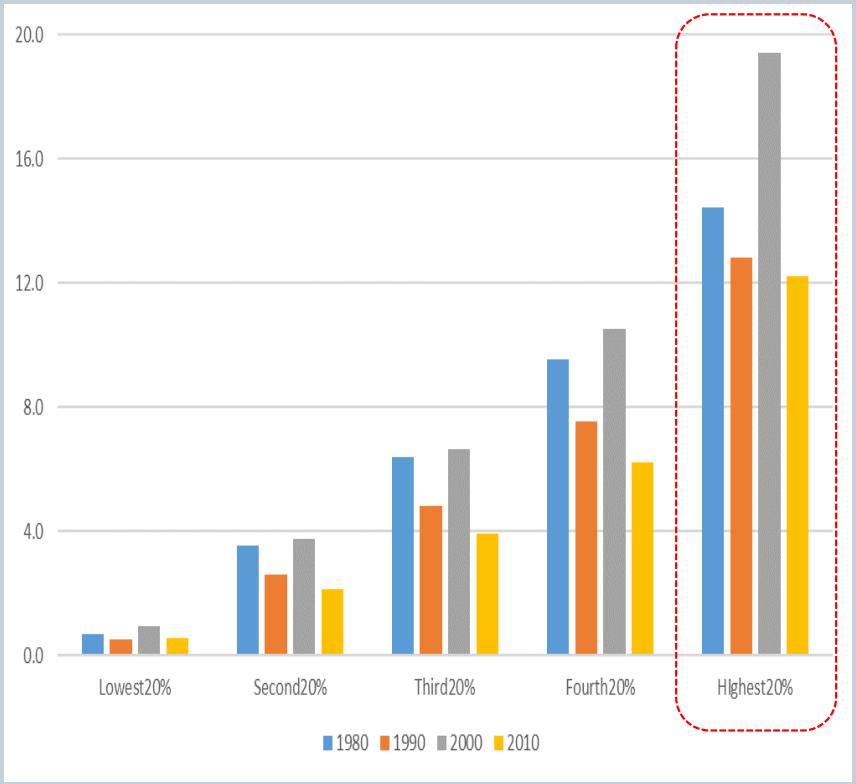
Origin of one unit of income shock

Note: **Column sums** of interrelational income multipliers

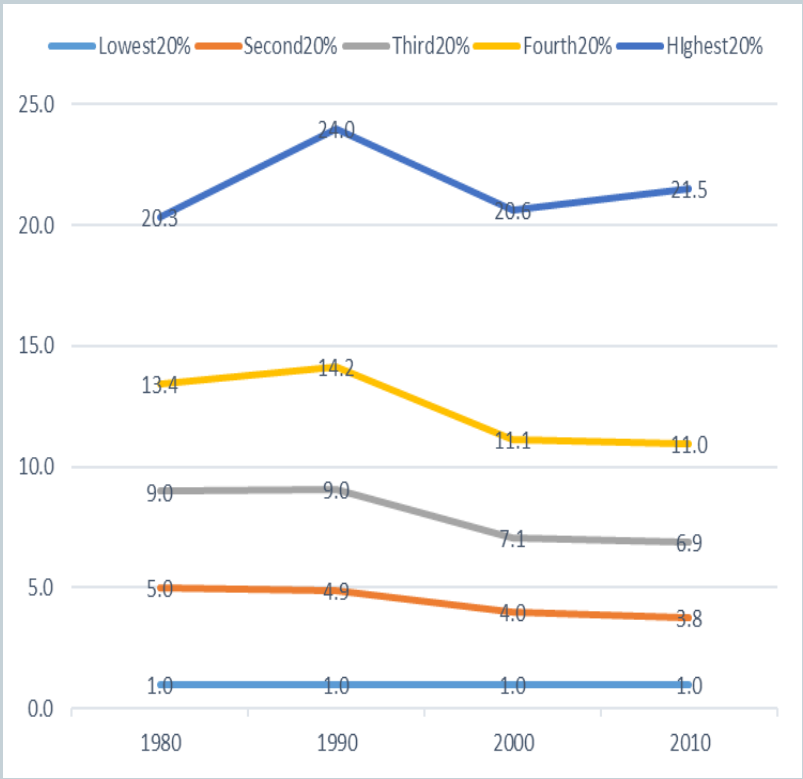
Evolution of interrelational income multipliers in Chicago (3)

- The highest 20% group receives the highest income generated when all income groups get one unit of income shock.
- When all income groups get equal income shocks, the relative amount of income received by the highest income group rose over the last three deceases while those by the rest groups fell.

Total income generated by one unit of income shock to all income group



Ratios of total income generated by one unit of income shock to all income group (lowest=1)



Note: **Row sums** of interrelational income multipliers

Evolution of multisector income multipliers in Chicago

Sector of final demand origion

Income group of income receipt	1980	1 Resourc	2 Constru	3 Non-Durable	4 Durable	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
	Lowest20%	0.09	0.10	0.10	0.10	0.08	0.09	0.05	0.11	**0.71**
	Second20%	0.44	0.52	0.49	0.50	0.41	0.44	0.25	0.53	**3.57**
	Third20%	0.76	0.96	0.87	0.91	0.77	0.79	0.44	0.90	**6.39**
	Fourth20%	1.14	1.46	1.30	1.36	1.14	1.18	0.65	1.33	**9.56**
	HIghest20%	1.71	2.18	1.97	2.03	1.72	1.80	1.03	2.02	**14.45**
	Col. Sum	**4.13**	**5.22**	**4.72**	**4.89**	**4.12**	**4.30**	**2.41**	**4.90**	**34.68**

Income group of income receipt	1990	1 Resourc e	2 Constru ction	3 Non-Durable s	4 Durable s	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
	Lowest20%	0.07	0.08	0.07	0.07	0.06	0.07	0.04	0.09	**0.53**
	Second20%	0.34	0.38	0.33	0.34	0.29	0.33	0.19	0.40	**2.60**
	Third20%	0.60	0.74	0.60	0.65	0.58	0.61	0.34	0.71	**4.84**
	Fourth20%	0.92	1.19	0.94	1.01	0.90	0.96	0.54	1.10	**7.57**
	HIghest20%	1.55	1.96	1.61	1.72	1.49	1.64	0.99	1.88	**12.84**
	Col. Sum	**3.48**	**4.35**	**3.53**	**3.80**	**3.33**	**3.62**	**2.09**	**4.18**	**28.38**

Income group of income receipt	2000	1 Resourc e	2 Constru ction	3 Non-Durable s	4 Durable s	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
	Lowest20%	0.13	0.14	0.11	0.12	0.11	0.12	0.07	0.15	**0.94**
	Second20%	0.49	0.58	0.44	0.47	0.45	0.47	0.29	0.57	**3.75**
	Third20%	0.85	1.06	0.78	0.83	0.81	0.83	0.51	0.99	**6.66**
	Fourth20%	1.32	1.69	1.22	1.32	1.27	1.32	0.82	1.55	**10.51**
	HIghest20%	2.39	3.03	2.30	2.44	2.32	2.46	1.59	2.89	**19.42**
	Col. Sum	**5.17**	**6.50**	**4.84**	**5.18**	**4.96**	**5.20**	**3.28**	**6.16**	**41.28**

Income group of income receipt	2010	1 Resourc e	2 Constru ction	3 Non-Durable s	4 Durable s	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
	Lowest20%	0.09	0.08	0.06	0.06	0.07	0.07	0.04	0.09	**0.57**
	Second20%	0.31	0.32	0.25	0.25	0.26	0.27	0.15	0.33	**2.14**
	Third20%	0.52	0.61	0.45	0.47	0.51	0.49	0.27	0.59	**3.92**
	Fourth20%	0.78	1.01	0.72	0.76	0.79	0.79	0.45	0.93	**6.24**
	HIghest20%	1.47	1.88	1.46	1.49	1.52	1.58	0.99	1.83	**12.23**
	Col. Sum	**3.17**	**3.91**	**2.95**	**3.03**	**3.16**	**3.20**	**1.90**	**3.78**	**25.09**

Evolution of multisector income multipliers in Chicago – Cont'd

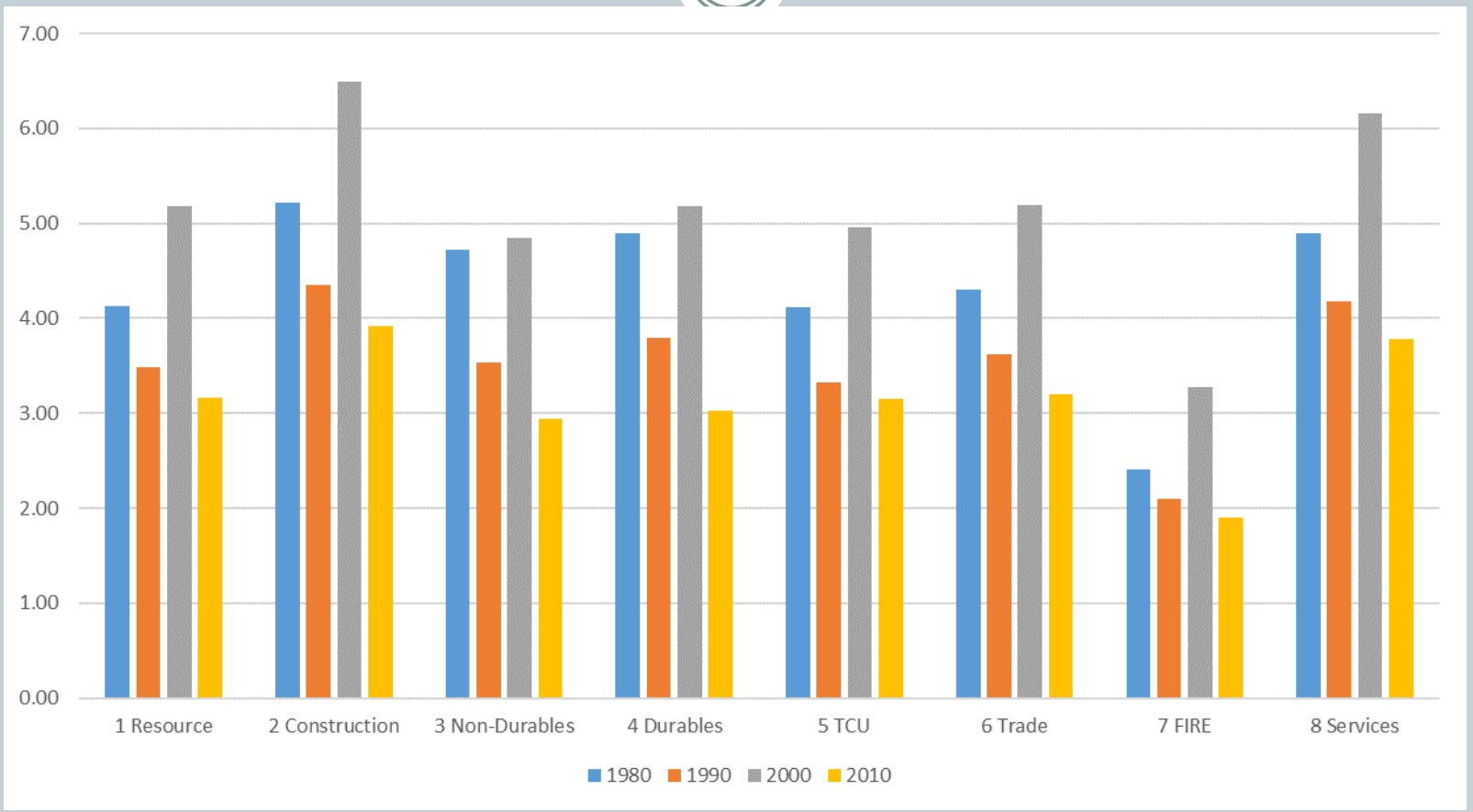
Percentage changes in indirect impacts

1990-1980	1 Resource	2 Construction	3 Non-Durables	4 Durables	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
Lowest20%	-16.0	-24.5	-31.6	-30.0	-26.4	-22.9	-24.0	-22.3	**-24.8**
Second20%	-22.8	-26.5	-33.4	-31.4	-27.3	-24.6	-25.3	-23.8	**-27.1**
Third20%	-21.1	-22.7	-31.2	-28.3	-24.2	-22.8	-21.5	-20.6	**-24.3**
Fourth20%	-19.0	-18.0	-27.9	-25.2	-21.5	-18.4	-17.1	-17.3	**-20.8**
HIghest20%	-9.3	-10.2	-18.2	-15.2	-13.1	-8.5	-4.0	-7.2	**-11.2**
Col. Sum	**-15.7**	**-16.6**	**-25.1**	**-22.3**	**-19.2**	**-15.8**	**-13.3**	**-14.6**	**-18.1**

2000-1990	1 Resource	2 Construction	3 Non-Durables	4 Durables	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
Lowest20%	72.4	85.8	62.8	68.0	90.5	76.1	93.5	71.2	**76.3**
Second20%	46.6	51.1	34.5	35.9	52.8	41.4	54.4	42.0	**44.2**
Third20%	42.1	42.0	30.1	28.1	39.1	36.0	48.9	39.1	**37.6**
Fourth20%	42.7	41.7	30.6	30.5	41.0	36.9	51.1	41.0	**38.8**
HIghest20%	54.2	54.8	42.9	41.6	55.3	49.7	61.6	53.9	**51.3**
Col. Sum	**48.7**	**49.2**	**37.1**	**36.3**	**49.0**	**43.7**	**56.7**	**47.2**	**45.4**

2010-2000	1 Resource	2 Construction	3 Non-Durables	4 Durables	5 TCU	6 Trade	7 FIRE	8 Services	Row sum
Lowest20%	-29.6	-41.2	-41.8	-44.1	-38.3	-39.9	-47.8	-38.6	**-39.6**
Second20%	-37.4	-44.2	-43.0	-46.0	-42.8	-42.9	-49.5	-41.6	**-43.1**
Third20%	-39.0	-41.8	-41.9	-43.9	-36.7	-40.8	-47.0	-40.6	**-41.2**
Fourth20%	-40.7	-40.2	-40.8	-42.7	-37.5	-39.9	-44.8	-40.0	**-40.6**
HIghest20%	-38.5	-37.9	-36.5	-38.9	-34.3	-35.9	-37.6	-36.5	**-37.0**
Col. Sum	**-38.8**	**-39.8**	**-39.2**	**-41.4**	**-36.4**	**-38.4**	**-42.1**	**-38.6**	**-39.2**

Evolution of multisector income multipliers in Chicago – Cont'd



Note: **Column sums** of multisector income multipliers

Summary

- The extended input-output results confirm common beliefs that
  1. the lowest income group is the largest income generator due to its larger propensity to consume.
  2. the highest income group is the largest income receiver due to its larger labor income share of production.
- The lowest income group generate 2.5 to 3 times as high total income as the highest income group does.
- When all income groups get equal income shocks, the relative amount of income received by the highest income group rose while those by the rest groups fell over the last three deceases.

Conclusions

- The Miyazawa analysis suggests that the effects of aging population on multipliers significantly vary across age group and sector despite modest total effects.
  - Under the econometric input-output framework, Kim, Hewings and Kratena (2015) show similar results.

- Labor demand policy aimed at specific age group must consider (at least) heterogeneity by sector.
  - A labor policy that intends to influence price of labor for the youngest group needs to be differentiated by sector,
  - while a labor policy targeting the oldest group's wages is expected to produce similar outcomes regardless of sector.

Summary: Policy Implications

- Income distribution is becoming more unequal
- The loss of middle income (mainly manufacturing jobs over the last 30 years has been a major contributor)
- Share of income received from non wage and salary income increases with income; returns to capital have grown much faster than returns to labor income (see Piketty) – further worsening the income distribution
- During the COVID-19 pandemic, distribution further deteriorated as higher income households spent less money on restaurants and entertainment, thereby reducing lower income households of a source of income
- Initial stimulus (providing additional $600/week) did reduce inequality; some support for a guaranteed income

Future Work

- Structural decomposition analysis (SDA)
  - Decomposition of changes in economic multipliers into changes in technology, final demand and **income distribution**
- Capital income – Social Account Matrix (SAM) – but problems:
  - Tracing source of this income
  - Will it be spent similarly to wage & salary income (pooling idea) or on different sets of goods and services?
  - Tracing the location of expenditures (multiple residences)
- Adding more heterogeneity like age, sex and skills
- Developing Persky-Felsenstein/Oosterhaven-van Dijk employment vacancy-chains (TiHC) to complement TiVA production chains

Application to São Paulo

- Consider an aggregation of *municipios* in São Paulo to 6-8 regions
- What do we know about commuting patterns? [In US cities, downtown still largest concentration of jobs with some residents (especially Millennials living/working in the area while others commute long distances from suburbs]
- Are shopping trips longer/more diffused than work trips?
- What are your expectations for the Miyazawa-style income dynamics?
- How has the *bolsa familia* changed the income distribution dynamics?

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