Structural Change with Endogenous Input-Output Linkages

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Structural Change: Recent US Evidence

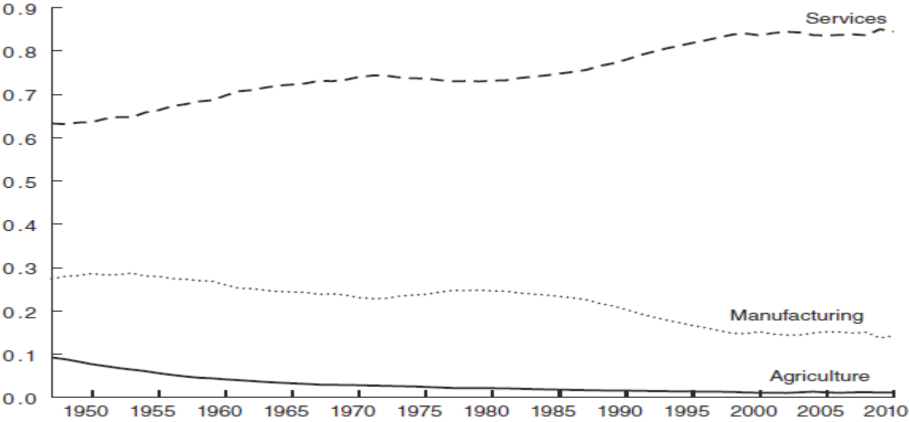

Figure: Value added share

- From Herrendorf, Rogerson, and Valentinyi (13)
- Consumption share

Leading Interpretations

Leading theories focus on consumer preference and income

- Price effects: sector-biased technological change and complementary preferences
- Income effects: sector-biased income elasticity
- Recent studies show importance of both effects

literature

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Leading theories silent on producer *interactions* and heterogeneity

- Producers are interconnected by input-output linkages
- Producers buy and sell intermediate-inputs (I-I)
- External outsourcing of I-I induces mobility of labor and capital and generates structural change (SC)

Main Idea

Suppose outsourcing cost $\downarrow$ from sector S to sector M

- Producer in M has incentive to buy more I-I
- Producer in S is profitable to supply more I-I
- Evidence: $\downarrow$ coordination and monitoring cost induces external outsourcing from M to S (Weil 14; Goldschmidt et al. 17)

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- Relies more on outsourcing $\Longrightarrow$ labor & capital move away

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SC from M to S

example

Beyond Leading Theories

This paper proposes a new theory for structural change

- endogenizes input-output linkages: Ricardian trade
- complements the literature on structural change

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This paper does not consider

- organizational factors or management strategies
- international trade and offshoring

Result Preview

Quantifying the four effects

- I-I supply effects (SE) are essential, comparable to price effect (PE)
- I-I demand effect (DE) and Income effect (IE) are less important.

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Relative to manufacturing,

- services $\uparrow$ comparative advantage supplying I-I
- services $\uparrow$ TFP scale; $\downarrow$ outsourcing supply cost

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Discussion of implication

- producer interaction and heterogeneity are non-neutral
- productivity slowdown may be overstated by the SC literature

Roadmap

1. Introduction
2. Empirical Evidence
3. Model
4. Quantifying the Importance of the Four Effects
5. Quantifying the I-I Supply Channel
6. Conclusion

Empirical Evidence

Two Sufficient Statistics

Network view of input-output linkages

- B: input-output matrix example
- $B1$: total intensity of I-I supply with 1 unit of length
- $B^2 1$: total intensity of I-I supply with 2 unit of length
- $B^N 1$: total intensity of I-I supply with N unit of length

I-I supply multiplier: $\mu^s \equiv (I - B)^{-1} 1 = (I + B + B^2 + ... + B^\infty) 1$

- Total direct and indirect I-I connections to downstream sectors

I-I demand multiplier: $\mu^d \equiv 1'(I - B)^{-1} = 1'(I + B + B^2 + ... + B^\infty)$

- Total direct and indirect I-I connections to upstream sectors

Empirical Evidence

1. VA share ↑ with I-I supply multiplier; ↓ with I-I demand multiplier
   - Four Sectors: Manufacturing (Manu), market service (MS), non-market service (NMS), other good (OG)
   - 35 major economies, during 1995-2007

VA Share Increases with I-I Supply Multiplier

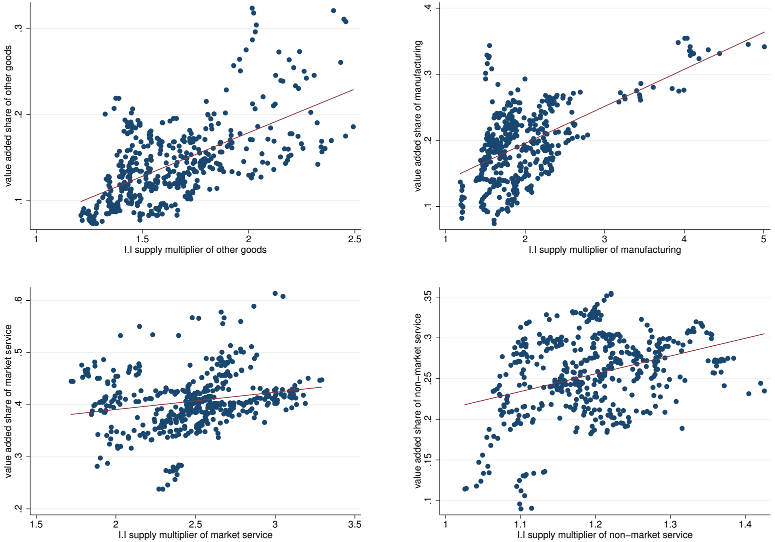

Figure: Value added share and intermediate input supply multiplier

VA Share Decreases with I-I Demand Multiplier

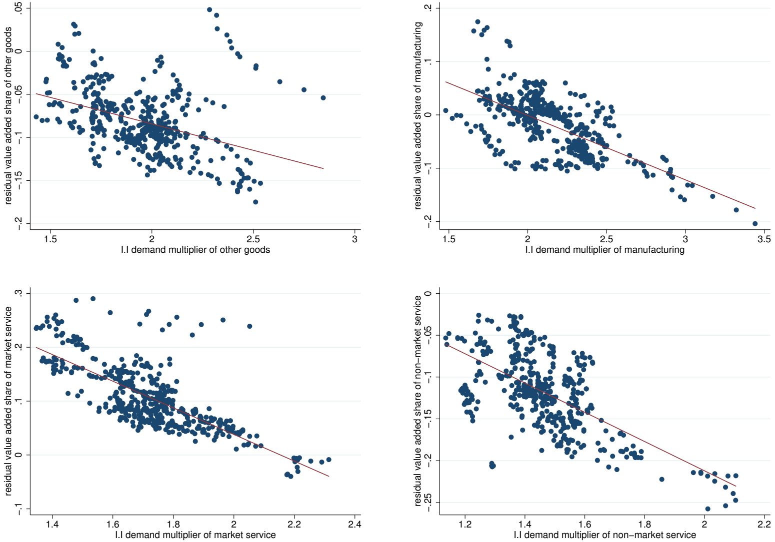

Figure: Residual VA share and intermediate input demand multiplier

Empirical Evidence

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   - Four Sectors: Manufacturing (Manu), market service (MS), non-market service (NMS), other good (OG)
   - 35 major economies, during 1995-2007

2. Sectoral gross output share of GDP (Domar weight) $\uparrow$ with I-I supply multiplier.

Domar Weight Increases with I-I Supply Multiplier

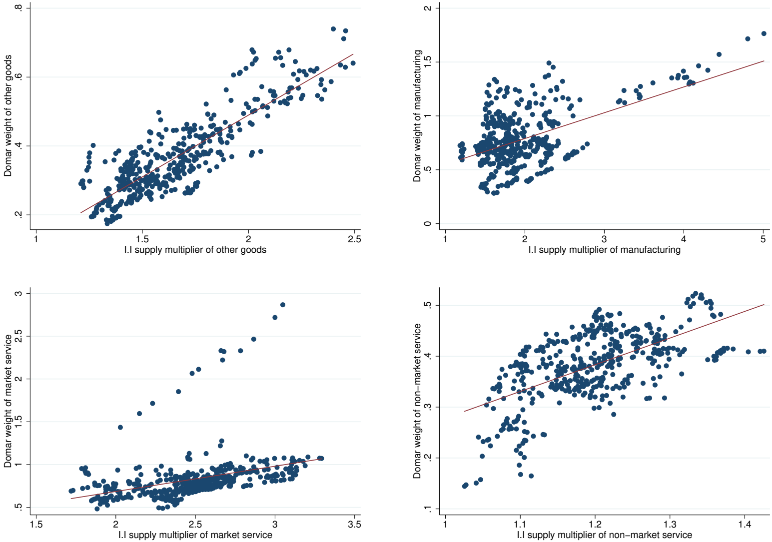

Figure: Domar weight and intermediate input supply multiplier

Model

Preferences

- From Comin, Lashkari and Mestieri (18)
- Nonhomothetic CES in aggregate consumption:
  $\sum_{i=1}^{n} \Omega_i^{\frac{1}{\varepsilon}} C_t^{\frac{\epsilon_i - \varepsilon}{\varepsilon}} C_{it}^{\frac{\varepsilon - 1}{\varepsilon}} = 1$
- ε is elasticity of substitution between sectoral consumption.
- ϵ_i measures the income elasticity of demand.
- If $\epsilon_i = 1$, $C_t = \left(\sum_{i=1}^{n} \Omega_i^{\frac{1}{\varepsilon}} C_{it}^{\frac{\varepsilon - 1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon - 1}}$

Advantages

- Isolate income effects from price effects
- Stable income elasticity, consistent with data

Technology

- Nonhomothetic CES in aggregate output: $\sum_{i=1}^{n} \Psi_{it}^{\frac{\kappa}{\rho}} Q_t^{\frac{\xi_i - \rho}{\rho}} Q_{it}^{\frac{\rho-1}{\rho}} = 1$
- Sectoral output is CES aggregate of I-I: $Q_{it} = \left(\sum_{j=1}^{n} X_{ijt}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}}$
- I-I is CES aggregate of firm-level I-I varieties or tasks:
$X_{ijt} = \left[\int_0^1 X_{ijt}(\omega)^{\frac{\nu-1}{\nu}} d\omega \right]^{\frac{\nu}{\nu-1}}$

Key features

- $\Psi_{it} \uparrow$ with μ_{it}^{s}, motivated by evidence 2 and mechanism
- Ψ_{it} is state variable for aggregate producer
- Isolate I-I supply effect from price and income effects

A Binary Version of Eaton and Kortum (02)

I-I Variety is produced in-house or by outsourcing (Boehm 18):

- $P^*_{ijt}(\omega) = \min(P^H_{ijt}(\omega), P^X_{ijt}(\omega))$

Production in-house: $X^H_{ijt}(\omega) = a^H_{ijt}(\omega) k^{\alpha}_{ijt}(\omega) l^{1-\alpha}_{ijt}(\omega)$

- $\omega \in [0, 1]$
- Frechet distributed TFP: $\Pr[a^H_{ijt} \leq a] \equiv F_{it}(a) = e^{-T_{it} a^{-\zeta}}$

Outsourcing: $X^X_{ijt}(\omega) = a^X_{ijt}(\omega) Q_{ijt}(\omega)$

- Frechet distributed TFP: $\Pr[a^X_{ijt} \leq a] \equiv F_{jt}(a) = e^{-T_{jt} a^{-\zeta}}$
- Iceberg outsourcing cost τ_{ijt} applies.

Structural Change in Consumption

Consumption share

$$\log\frac{\lambda_{it}}{\lambda_{jt}} = \log\frac{\Omega_i}{\Omega_j} + (1-\varepsilon)\log\frac{P_{it}}{P_{jt}} + (\epsilon_i - \epsilon_j)\log C_t$$

- PE ($\varepsilon < 1$): structural change from relatively ↓ price to ↑ price sector.
- IE: structural change from lower elastic to higher elastic sector.
- Consistent with the literature.

Structural Change in Production

Value added share

$$\log\frac{\eta_{it}}{\eta_{jt}} = \log\frac{1-\sigma_{it}}{1-\sigma_{jt}} + \kappa\log\frac{\Psi_{it}}{\Psi_{jt}} + (1-\rho)\log\frac{P_{it}}{P_{jt}} + (\xi_i - \xi_j)\log Q_t$$

- σ_{it} is I-I demand intensity
- Ψ_{it} is determined by I-I supply multiplier.
- DE: structural change to sectors with smaller growth of I-I demand multiplier
- SE: structural change to sectors with larger growth of I-I supply multiplier if $\kappa > 0$
- Income is aggregate gross output, rather than consumption.

Connection to literature

- $\frac{\eta_{it}}{\eta_{jt}} = \frac{\lambda_{it}}{\lambda_{jt}}$ if $B = I$, $\Psi_{it} = \Psi_i$, and same elasticities

Endogenous Input-Output Linkages and Prices

Intensity of input-output linkage

- $B_{jit} \equiv \frac{P_{ijt}X_{ijt}}{P_{it}Q_{it}} \frac{P^X_{ijt}X^X_{ijt}}{P_{ijt}X_{ijt}} = \left(\frac{P_{ijt}}{P_{it}}\right)^{-\theta} \frac{T_{jt}(P_{jt}\tau_{ijt})^{-\zeta}}{T_{jt}(P_{jt}\tau_{ijt})^{-\zeta}+T_{it}(\tilde{w}_{it}\tau_{iit})^{-\zeta}}$ intuition

Price

- Sectoral price: $P_{it} = \left[\sum_{j=1}^{n}(P_{ijt})^{-\theta}\right]^{-\frac{1}{\theta}}$ intuition
- I-I price: $P_{ijt} = \frac{\nu}{\nu-1}\left[\Gamma\left(\frac{1-\nu+\zeta}{\zeta}\right)\right]^{\frac{1}{1-\nu}}\left[T_{jt}(P_{jt}\tau_{ijt})^{-\zeta} + T_{it}(\tilde{w}_{it}\tau_{iit})^{-\zeta}\right]^{-\frac{1}{\zeta}}$
- Factor cost composite: $\tilde{w}_{it} = \left(\frac{r_{it}}{\alpha}\right)^{\alpha}\left(\frac{w_{it}}{1-\alpha}\right)^{1-\alpha}$

Quantifying the Importance of the Four Effects

Data

Model Estimate and Calibration

Regression to estimate elasticities in production side SC

- $\beta = 0.887, \kappa = 0.686, 1 - \rho = 0.503, \xi_{MS} - \xi_{Manu} = -0.029$ detail

Regression to estimate elasticities in consumption side SC

- $\varepsilon = 0.344, \epsilon_{MS} - \epsilon_{Manu} = 0.004$

Model Estimate and Calibration

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Regression to estimate elasticities in consumption side SC

- $\varepsilon = 0.344$, $\epsilon_{MS} - \epsilon_{Manu} = 0.004$

Trade cost, TFP scale, Trade and CES elasticities

- Suppose ζ, θ and ν are known; normalise $\tau_{iit} = 1$
- T_{it}, τ_{ijt} and $\tilde{w}_{it}$ exactly calibrated to match data: B_{jit} and P_{it}
- ζ and θ calibrated to minimize moment gap of wage growth detail
- Result: $\zeta = 2.701$, $\theta = 1.646$ and $\nu = 3.5$

Benchmark Decomposition of Structural Change

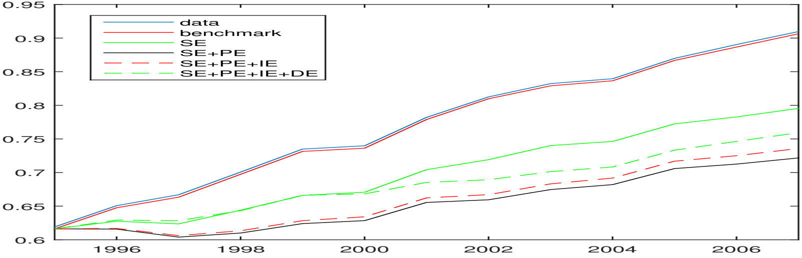

Figure: Relative value added share of market service to manufacturing

The four effects

- I-I supply effect: gap b/w red solid line and green solid line

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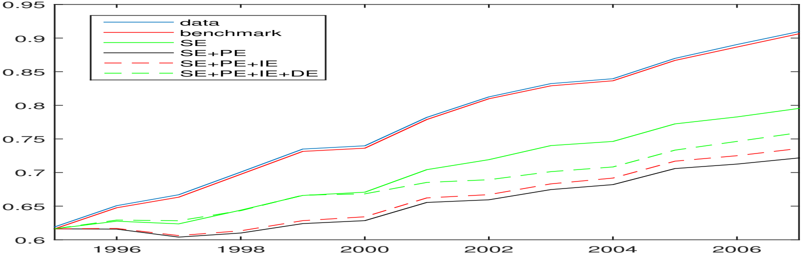

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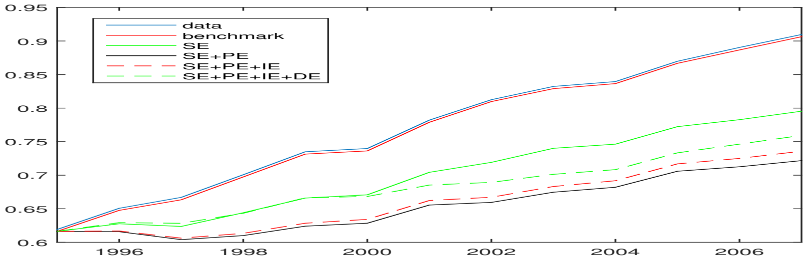

Figure: Relative value added share of market service to manufacturing

The four effects

- I-I supply effect: gap b/w red solid line and green solid line
- Price effect: gap b/w green solid line and black solid line
- Income effect: gap b/w black solid line and red dash line
- I-I demand effect: gap b/w red dash line and green dash line

Simulation and Decomposition

- Manipulate the calibrated primitives as in the following two cases
- Simulates DE, SE, PE and then structural change
- Re-estimate the four effects based on simulated data
- Re-do the decomposition exercises

1. Holding trade costs at the initial year level: $\tau_{ijt} = \tau_{ij,1995}$
    - $\beta = 0.926$, $\kappa = 0.865$, $1 - \rho = 0.182$, $\xi_{MS} - \xi_{Manu} = 0.031$.
2. Holding TFP scales at the initial year level: $T_{it} = T_{i,1995}$
    - $\beta = 1.005$, $\kappa = 1.151$, $1 - \rho = 0.468$, $\xi_{MS} - \xi_{Manu} = -0.010$.

Decomposition Under the First Simulation

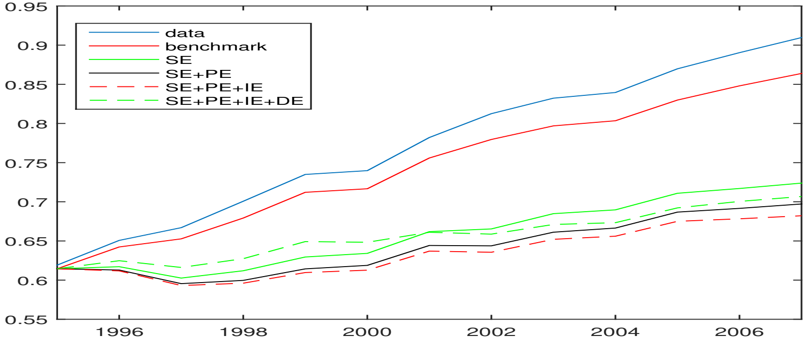

Figure: Relative value added share of market service to manufacturing

- I-I supply effect dominates structural change mechanisms

Decomposition Under the Second Simulation

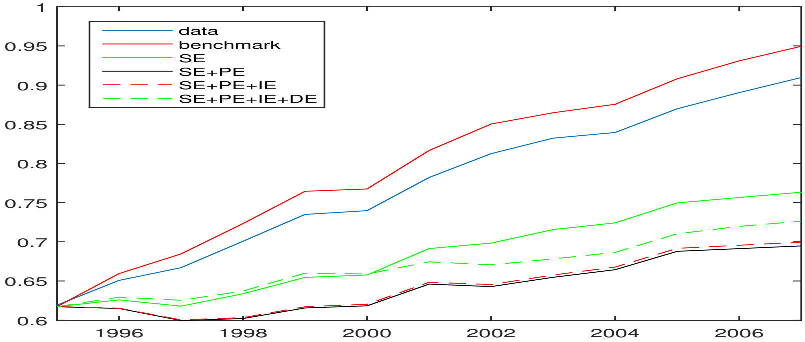

Figure: Relative value added share of market service to manufacturing

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Validation

- US long run data: 1947-2010. R1
- Sub-sample of developed countries and developing countries. R2
- Other values of ζ and θ. R3
- OG to Manu; NMS to Manu. R4
- Employment share. R5
- Impose $\beta = 1$. R6

Quantifying the I-I Supply Channel

How Divergent Are Outsourcing Supply Cost?

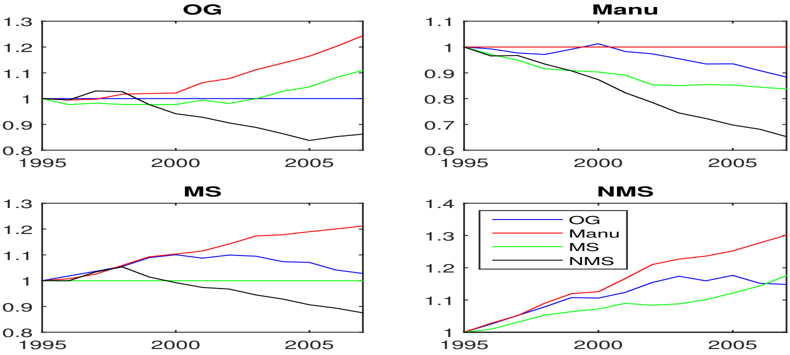

Figure: World average outsourcing supply cost at sector-pair

- S have lower growth of outsourcing supply cost, relative to M

How Divergent Are TFP scale Growth?

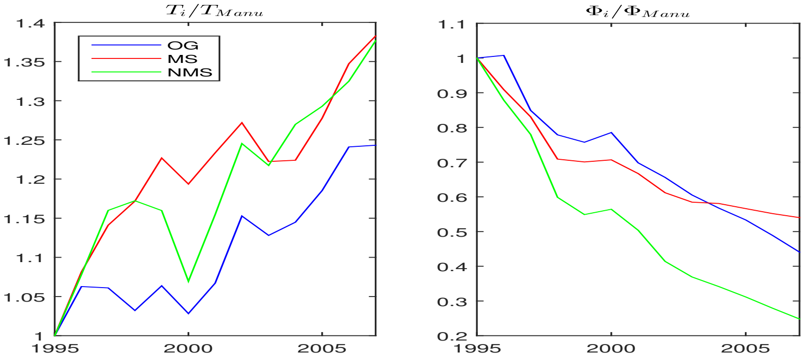

Figure: Relative sectoral TFP and efficiency at world average efficiency

- S have higher growth of TFP scale, relative to M
- S have lower growth of overall efficiency, relative to M

Counterfactual Setup

Counterfactual study to show importance of outsourcing supply cost

1. Suppose MS has same growth path of outsourcing supply cost as Manu.
2. Compare relative VA share and I-I supply multiplier.

Counterfactual study to show importance of TFP scale

1. Suppose MS has same growth path of TFP scale as Manu.
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Role of Outsourcing Supply Cost

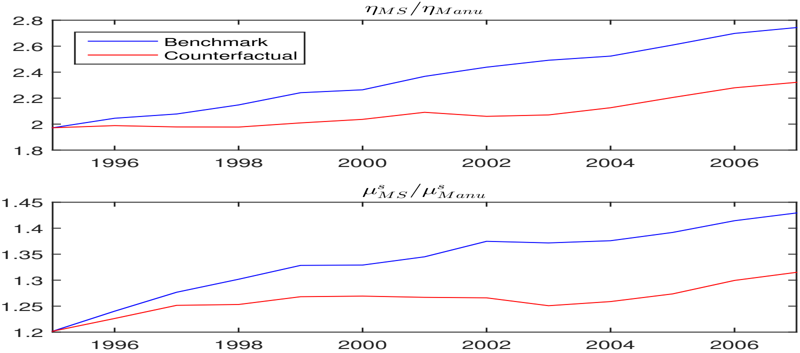
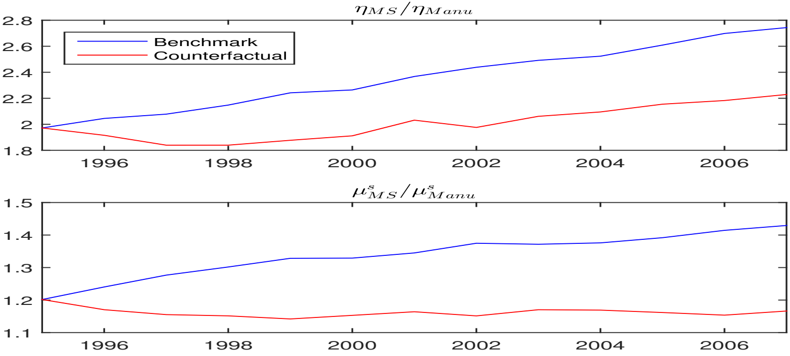


Figure: Relative VA share and I-I supply multiplier of MS to Manu more

- Without growing comparative advantage from outsourcing supply cost, relative VA share and I-I supply multiplier ↑ by less proportion

Role of TFP Scale



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Role of ζ

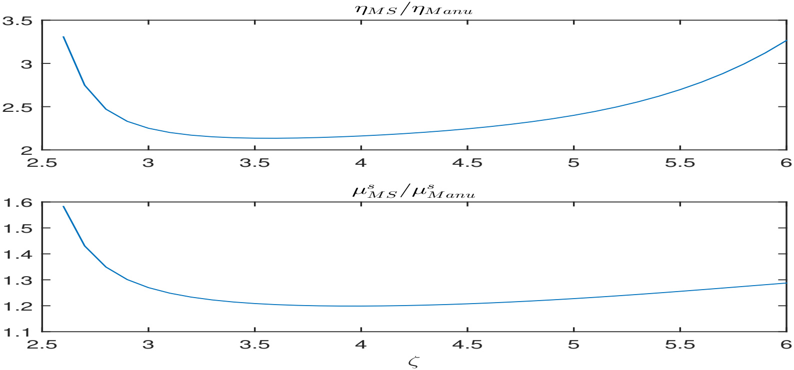

Figure: Relative value added share and I-I supply multiplier of MS to Manu

- Structural change positively depends on I-I supply capacity, as we move trade elasticity

Conclusion

- A new prominent mechanism to explain VA share based SC
- Heterogeneous growth path of TFP scale and trade cost motivates outsourcing
- Outsourcing generates SC through I-I supply channel
- Given SC reflects outsourcing, TFP slowdown may be overstated
- Producer interaction and heterogeneity matter at least in SC study

Thank You

Appendix

Structural Change: Recent US Evidence

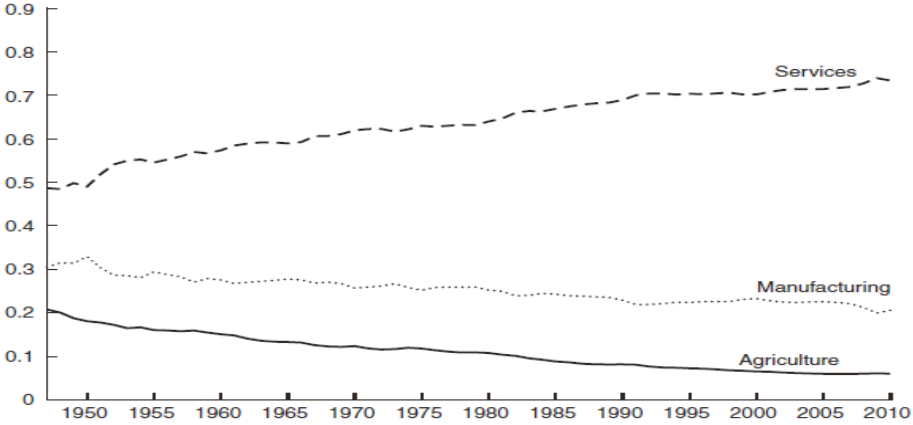

Figure: Consumption share

- From Herrendorf, Rogerson, and Valentinyi (13)
- back

Literature

Structural change

- PE: Ngai and Pissarides (07)
- IE: Kongsamut, Rebelo and Xie (01)
- PE + IE: Comin, Lashkari and Mestieri (18)
- outsourcing: Berlingieri (14); Sposi (18)

Ricardian trade

- International trade + multi-country + final output: Eaton and Kortum (02)
- Domestic outsourcing + multi-sector + I-I: Boehm (18)

back

Recent US Evidence

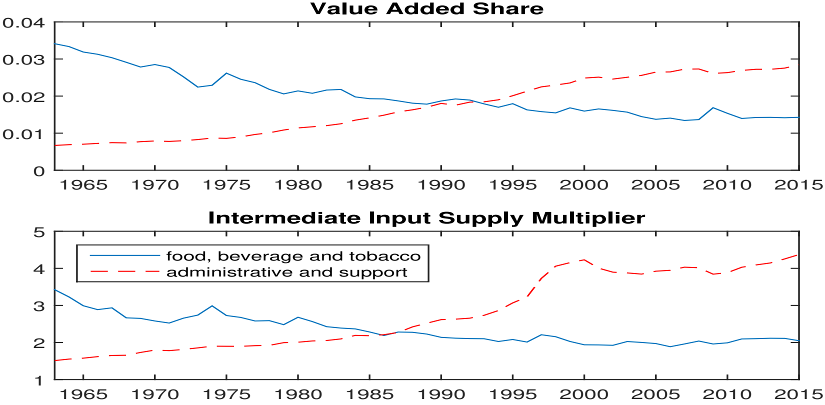

Figure: Value added share and intermediate-inputs supply capacity

- Value added share ↑ with I-I supply capacity
- back

Thought Experiment

Benchmark					SC				
	I-IS1	I-IS2	C	Q		I-IS1	I-IS2	C	Q
I-ID1	1	1	2	4	I-ID1	1	2	2	5
I-ID2	1	1	2	4	I-ID2	1	1	2	4
VA	2	2			VA	3	1		
Q	4	4			Q	5	4		

- I-IS1+I-IS2+C=Q=I-ID1+I-ID2+VA
- Holding constant basic prices and income

Structural change story back

1. Shock of outsourcing cost $\Longrightarrow$ S2 can outsource to S1 more easily
2. S2 relies on more I-I outsourcing, shifting out labor and capital
3. S1 needs to supply more I-I, hiring additional labor and capital
4. Structural change from S2 to S1.

Take away: SC from relatively demandable sector to suppliable sector

Input-Output Table and B Matrix

Table 1				
	I-IS1	I-IS2	C	Q
I-ID1	1	1	2	4
I-ID2	1	1	2	4
VA	2	2		
Q	4	4		

Table 2				
	I-IS1	I-IS2	C	Q
I-ID1	1	2	2	5
I-ID2	1	1	2	4
VA	3	1		
Q	5	4		

- I-IS1+I-IS2+C=Q=I-ID1+I-ID2+VA
- In table 1, B= $\begin{bmatrix} 0.25 & 0.25 \\ 0.25 & 0.25 \end{bmatrix}$
- In table 2, B= $\begin{bmatrix} 0.2 & 0.5 \\ 0.2 & 0.25 \end{bmatrix}$
- back

Partial Equilibrium: SC Implication of Linkage

Multi-Sector Model with Input-Output Linkage

- Partial and competitive equilibrium model from Jones (2011).
- Inelastically supplied capital and labor
- Output and input markets clear
- Nominal accounting entities always hold at sector level

- Sectoral gross output: $Q_i = A_i K_i^{(1-\sigma_i)\alpha_i} L_i^{(1-\sigma_i)(1-\alpha_i)} \prod_{j=1}^{n} (X_{ij}^X)^{\sigma_{ij}}$
- Aggregate value added: $Y = \prod_{i=1}^{n} C_i^{\lambda_i}$
- Budget constraint: $C_j + \sum_{i=1}^{n} X_{ij}^X = Q_j$

Mechanism and Intuition

Leontief inverse

- B is matrix of input-output linkage.
- $L = (I - B)^{-1}$.
- $\uparrow A_i$ by 1 percent $\Longrightarrow \uparrow Q_j$ by l_{ij} percent

Domar weight

- $\uparrow Q_j$ by l_{ij} percent $\Longrightarrow \uparrow Y$ by γ_i percent
- $\gamma_i = \sum_{j=1}^{n} l_{ij}\lambda_j$; γ_i is TFP elasticity (Q_i based).
- $\eta_i = (1 - \sigma_i)\gamma_i$; η_i is TFP elasticity (Y_i based).

Mechanism

- Assume symmetric preference ($\lambda_i = \lambda_j$) $\Rightarrow$ focus on linkage effect
- $\uparrow$ I-I supply ($\uparrow \mu_i^s$) $\Rightarrow$ Domar intensity $\uparrow$ ($\gamma_i \uparrow$)$\Rightarrow$ TFP elasticity $\uparrow$ ($\eta_i \uparrow$)
- $\uparrow$ I-I demand ($\uparrow \mu_i^d$) $\Rightarrow$ I-I intensity $\uparrow$ ($\sigma_i \uparrow$)$\Rightarrow$ TFP elasticity $\downarrow$ ($\eta_i \downarrow$)

Fact 1

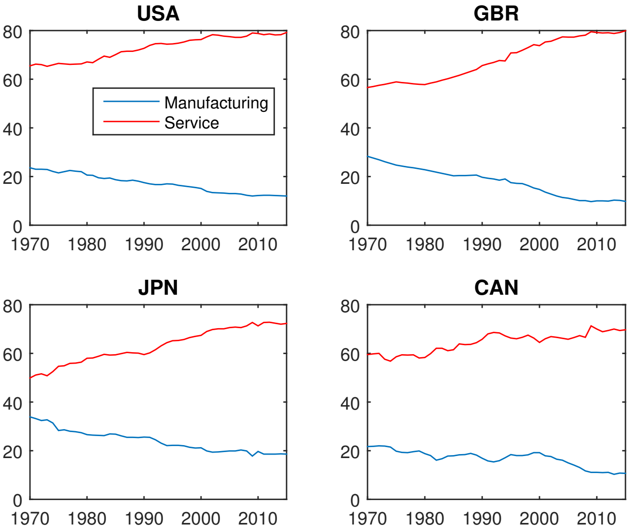

Figure: VA share of sample developed countries

Fact 1

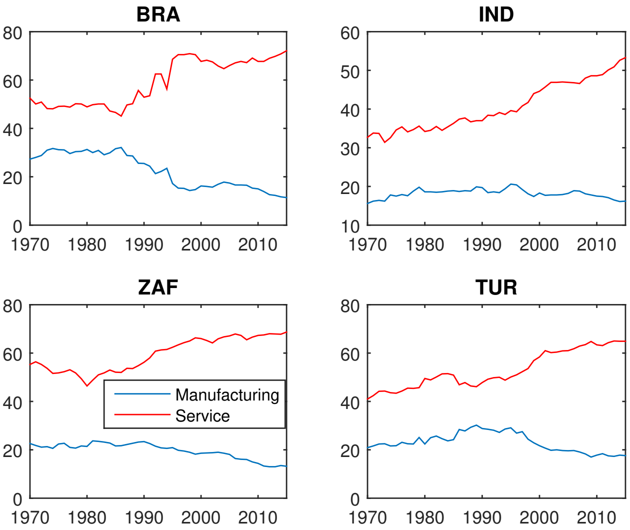

Figure: VA share of sample developing countries back

Fact 2

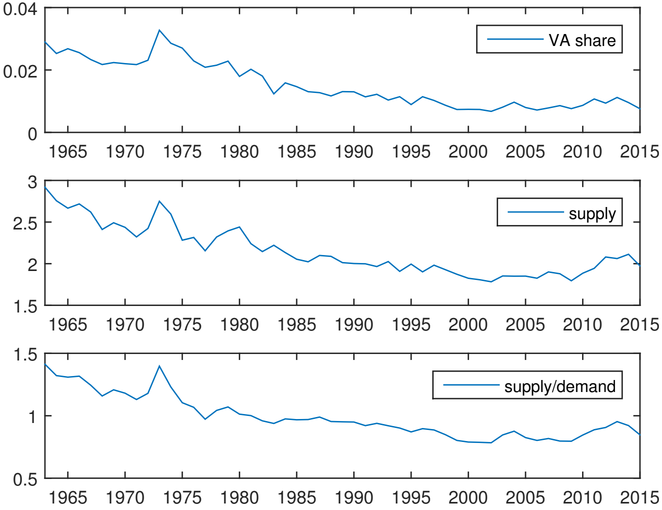

Figure: Farms

Fact 2

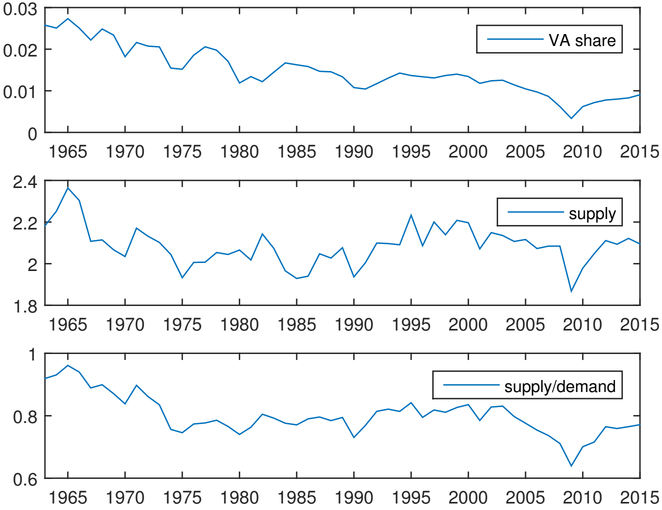

Figure: Motor vehicles, bodies and trailers, and parts

Fact 2

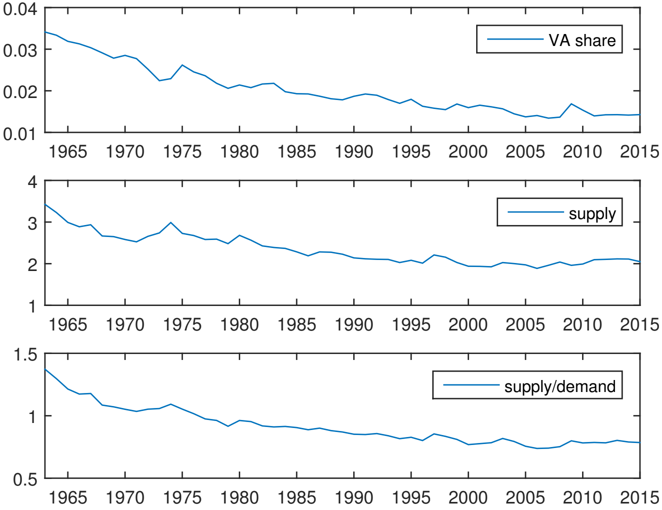

Figure: Food and beverage and tobacco products

Fact 2

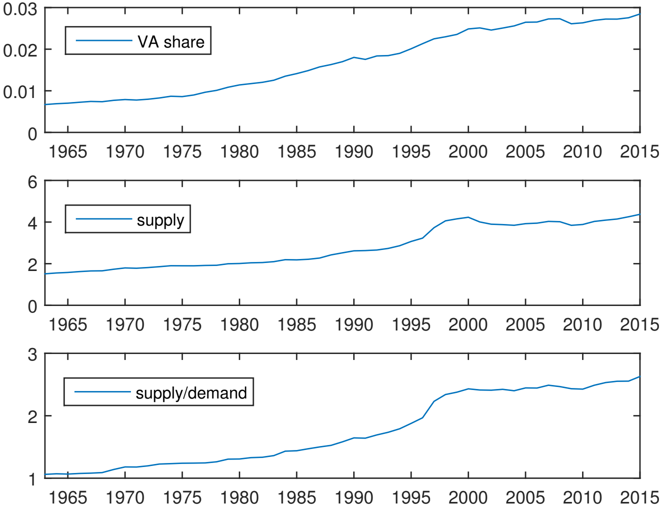

Figure: Administrative and support services

Fact 2

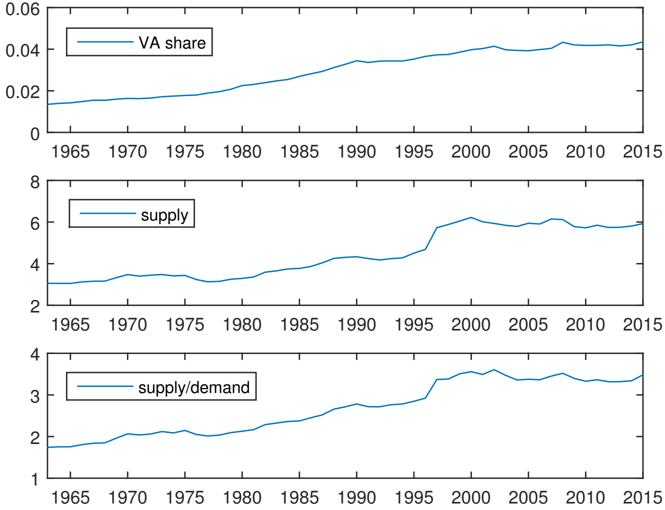

Figure: Miscellaneous professional, scientific, and technical services back

Fact 3

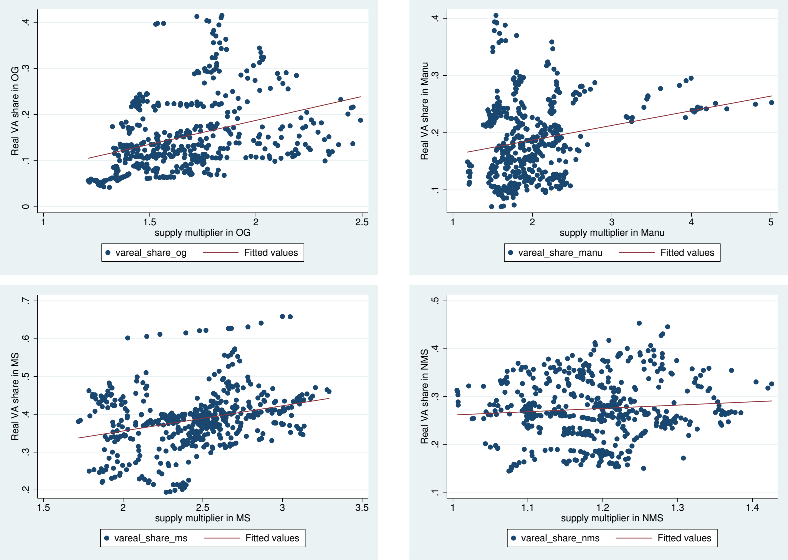

Figure: Sectoral supply multiplier and real value added share

Fact 3

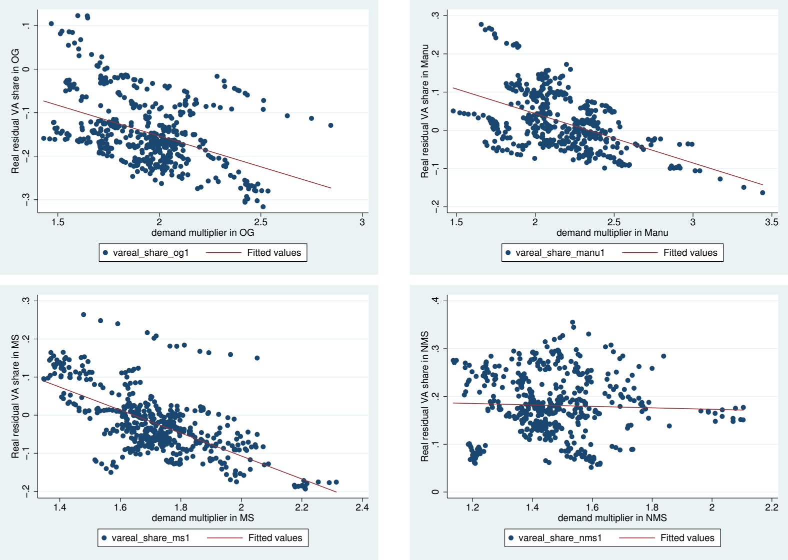

Figure: Sectoral demand multiplier and real residual value added share

Fact 5

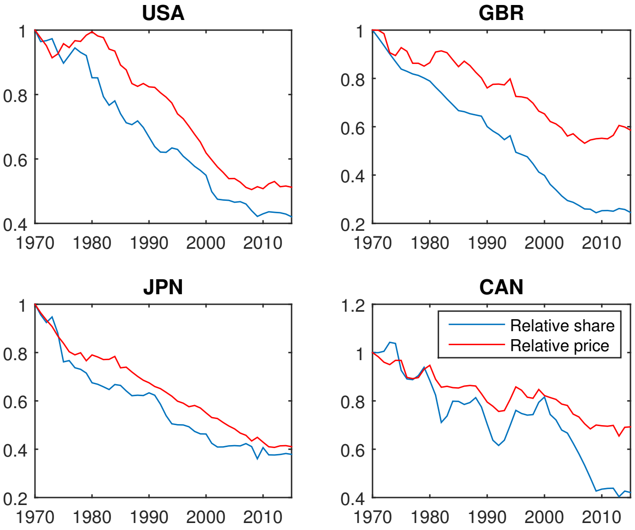

Figure: Nominal VA share of sample developed countries

Fact 5

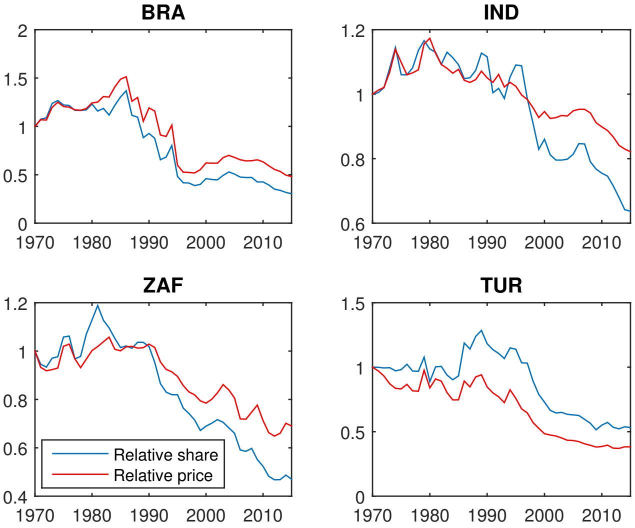

Figure: Nominal VA share of sample developing countries

Fact 5

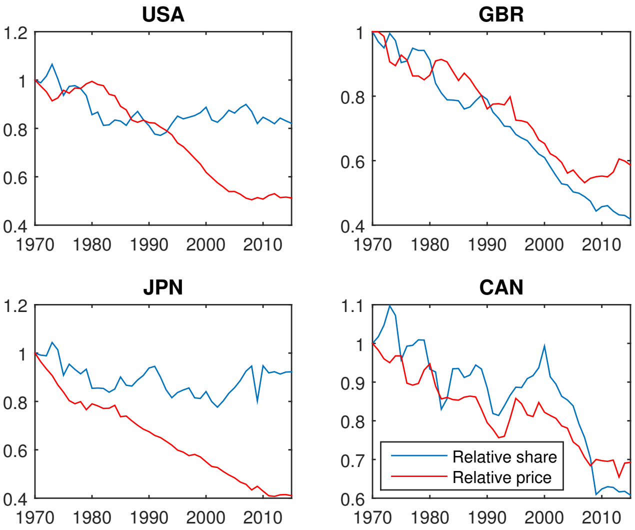

Figure: Real VA share of sample developed countries

Fact 5

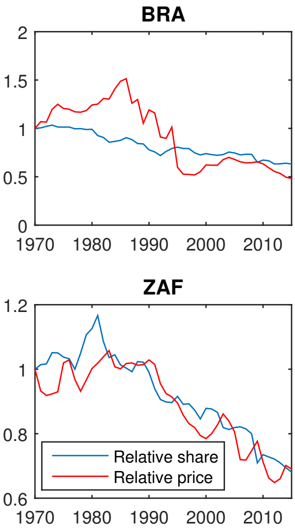

Figure: Real VA share of sample developing countries back

Preference

Intra-temporal sectoral consumption

$$\sum_{i=1}^{n} \Omega_i^{\frac{1}{\varepsilon}} C_t^{\frac{\epsilon_i - \varepsilon}{\varepsilon}} C_{it}^{\frac{\varepsilon - 1}{\varepsilon}} = 1 \tag{1}$$

- Nonhomothetic CES preference
- ε is elasticity of substitution between sectoral consumption.
- ϵ_i measures the income elasticity of demand.
- If $\epsilon_i = 1$, $C_t = \left(\sum_{i=1}^{n} \Omega_i^{\frac{1}{\varepsilon}} C_{it}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}$.

Sector Level Technology

Aggregate gross output

$$\sum_{i=1}^{n} \Psi_{it}^{\frac{\kappa}{\rho}} Q_t^{\frac{\xi_i - \rho}{\rho}} Q_{it}^{\frac{\rho-1}{\rho}} = 1 \tag{2}$$

- Nonhomothetic CES
- Time-varying weight: Ψ_{it}

Sectoral gross output

$$Q_{it} = \left(\sum_{j=1}^{n} X_{ijt}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}} \tag{3}$$

Intermediate input

$$X_{ijt} = \left[\int_0^1 X_{ijt}(\omega)^{\frac{\nu-1}{\nu}} d\omega \right]^{\frac{\nu}{\nu-1}} \tag{4}$$

Firm Level Technology

Production in-house

$$X^H_{ijt}(\omega) = a^H_{ijt}(\omega) k^{\alpha}_{ijt}(\omega) l^{1-\alpha}_{ijt}(\omega) \tag{5}$$

- Frechet distributed TFP: $\Pr[a^H_{ijt} \leq a] \equiv F_{it}(a) = e^{-T_{it}a^{-\zeta}}$

Outsourcing

$$X^X_{ijt}(\omega) = a^X_{ijt}(\omega) Q_{ijt}(\omega) \tag{6}$$

- Frechet distributed TFP: $\Pr[a^X_{ijt} \leq a] \equiv F_{jt}(a) = e^{-T_{jt}a^{-\zeta}}$

Binary Choice

$$P^*_{ijt}(\omega) = \min(P^H_{ijt}(\omega), P^X_{ijt}(\omega)) \tag{7}$$

- Iceberg sourcing cost τ_{ijt} applies. back

Estimate of Production Side Elasticities back

$$\log\frac{\eta_{it}}{\eta_{jt}} = \beta\log\frac{1-\sigma_{it}}{1-\sigma_{jt}} + \kappa\log\frac{\mu^s_{it}}{\mu^s_{jt}} + (1-\rho)\log\frac{P_{it}}{P_{jt}} + (\xi_i - \xi_j)\log Q_t$$

	Dependent Variable : $\log\frac{\eta_{it}}{\eta_{jt}}$						
Coefficient	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
β		1.486***	0.896***	0.887***	1.737***	0.970***	0.845***
		(0.065)	(0.045)	(0.042)	(0.083)	(0.053)	(0.056)
κ		1.406***	0.803***	0.686***	0.689***	0.646***	0.802***
		(0.046)	(0.037)	(0.037)	(0.036)	(0.044)	(0.055)
$1-\rho$	0.408***	0.272***	0.472***	0.503***	0.478***	0.547***	0.336***
	(0.028)	(0.026)	(0.030)	(0.029)	(0.029)	(0.043)	(0.037)
$\epsilon_{OG} - \epsilon_{Manu}$	-0.024**	0.020**	-0.073***	-0.059	-0.004	0.682***	0.012
	(0.011)	(0.008)	(0.028)	(0.052)	(0.051)	(0.070)	(0.068)
$\epsilon_{MS} - \epsilon_{Manu}$	-0.049***	-0.050***	0.190***	-0.029	0.044	0.452***	0.124**
	(0.009)	(0.008)	(0.022)	(0.041)	(0.040)	(0.059)	(0.054)
$\epsilon_{NMS} - \epsilon_{Manu}$	-0.050***	-0.008	0.073**	-0.097*	-0.011	0.022	0.291***
	(0.009)	(0.007)	(0.030)	(0.064)	(0.055)	(0.068)	(0.086)
Country FE	NO	NO	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	YES	YES	YES	YES
DE approx.	NO	NO	NO	NO	YES	NO	NO
Sample	ALL	ALL	ALL	ALL	ALL	DC	LDC

Estimate Strategy of ζ, θ and ν

Factor cost parameter in the model is $\tilde{w}_{it} = \left(\frac{r_{it}}{\alpha}\right)^{\alpha}\left(\frac{w_{it}}{1-\alpha}\right)^{1-\alpha}$

- Assume constant capital share and interest rate: $\alpha = \frac{1}{3}$; $r_{it} = r$
- Normalize $\tilde{w}_{it} = 1$ for US manufacturing at year 2005.
- Estimate wage as $w_{it} = \frac{w_{it}L_{it}}{L_{it}}$.
- Let model generated average growth rate of sectoral factor cost as $\Delta_M(\tilde{w}_i)$; the data estimated counterpart as $\Delta_D(\tilde{w}_i)$
- Jointly find ζ and θ to minimizes the moment gap:

$$(\zeta, \theta) = \arg\min \sum_c \sum_i [\Delta_D(\tilde{w}_i) - \Delta_M(\tilde{w}_i)]^2$$

Result

- $\zeta = 2.701$; $\theta = 1.646$
- Calibrate $\nu = 3.5$ to allow 40 percent mark-up (Boehm 2017).

back

Endogenous Price

- P_{ijt} consistent with final output price in Eaton and Kortum (2002).
- P_{ijt} inversely depends on outsourcing efficiency ($\Phi_{ijt} = T_{jt}(P_{jt}\tau_{ijt})^{-\zeta} + T_{it}(\tilde{w}_{it}\tau_{iit})^{-\zeta}$).
- Efficiency ↑ with TFP scale; ↓ with factor cost and outsourcing supply cost.
- P_{it} ↓ TFP scale; ↑ with factor cost and outsourcing supply cost.
- ζ determines how substitutable of production technology b/w in-house and outsourcing.

back

Endogenous Input-Output Linkage

- B_{jit} depends on I-I share and outsourcing share.
- I-I share adjusts at intensive margin.
- Outsourcing share adjusts at extensive margin.
- Outsourcing $\uparrow$ with TFP scale (absolute advantage).
- Outsourcing $\downarrow$ with factor cost and outsourcing supply cost.
- ζ is the sensitivity of outsourcing to relative cost.
- $\downarrow \zeta \implies$ outsourcing $\uparrow$ (comparative advantage)

back

Intuition

- Define $\Phi^X_{ijt} = T_{jt}(P_{jt}\tau_{ijt})^{-\zeta}$; $\Phi^H_{ijt} = T_{it}(\tilde{w}_{it}\tau_{iit})^{-\zeta}$
- $\Phi_{ijt} = \Phi^X_{ijt} + \Phi^H_{ijt}$
- Define ${\Phi_{it}}^{\frac{\theta}{\zeta}} = \sum_{j=1}^{n} {\Phi_{ijt}}^{\frac{\theta}{\zeta}}$ back
- Relative price inversely depend on relative efficiency:

$$\frac{P_{it}}{P_{jt}} = \left(\frac{\Phi_{it}}{\Phi_{jt}}\right)^{-\frac{1}{\zeta}} \tag{8}$$

- Relative home production share equals relatively weighted average of within sectoral home efficiency to I-I efficiency:

$$\frac{1-\sigma_{it}}{1-\sigma_{jt}} = \frac{\sum_{k=1}^{n}\left(\frac{\Phi_{ikt}}{\Phi_{it}}\right)^{\frac{\theta}{\zeta}} \frac{\Phi^H_{iit}}{\Phi_{ikt}}}{\sum_{k=1}^{n}\left(\frac{\Phi_{jkt}}{\Phi_{jt}}\right)^{\frac{\theta}{\zeta}} \frac{\Phi^H_{jjt}}{\Phi_{jkt}}}$$

Data

- World Input-Output Databse 2013 (WIOD)
  1. World Input-Output Tables (WIOT)
     (a) I-O Tables over 1995-2011.
     (b) 35 sectors; 40 countries.
  2. Socio Economic Account (SEA)
     (a) Nominal value of gross output (GO), VA, and sectoral intermediate input (I-I).
     (b) Price deflators of GO, VA, and I-I with base year 1995.
     (c) Total employee working hours.
     (d) Real fixed capital stock at year 1995 local price.
- Sector and Industry Relative Prices (Inklaar and Timmer 2014)
  (a) Sectoral GO and VA PPP deflators at 2005 global refrence prices.
  (b) Four sectors.
- Penn World Table (PWT) 8.1
  (a) PPP deflator for capital stock at 2005 global reference prices.
  (b) Annual average exchange rate.

back

Benchmark Decomposition of Structural Change

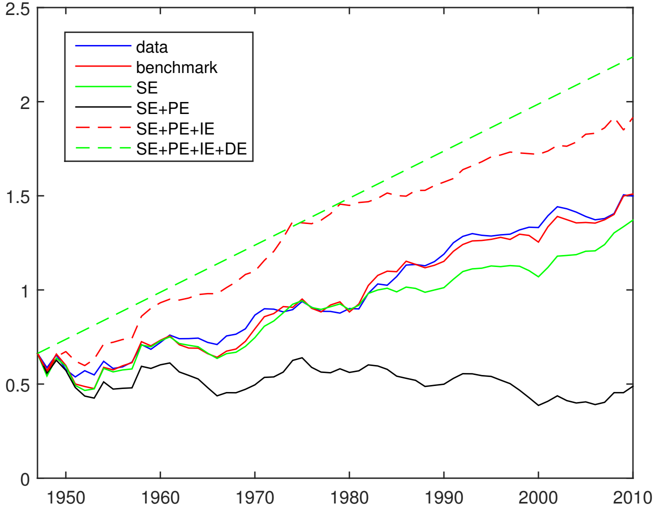

Figure: Relative VA share of service to manufacturing in US

Decomposition Under Counterfactual study 1

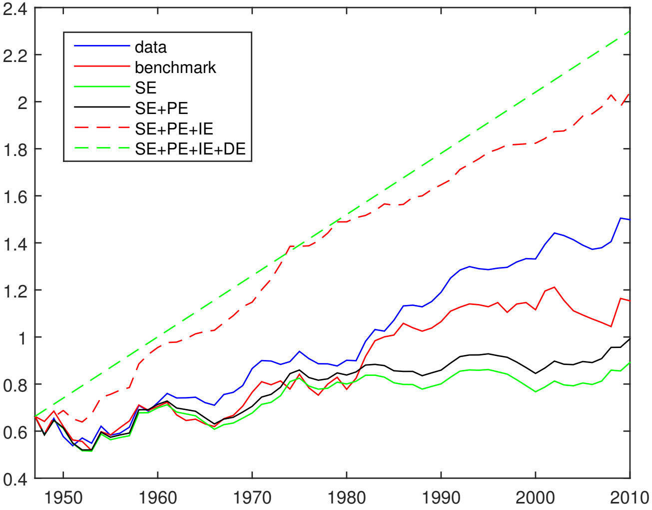

Figure: Relative VA share of service to manufacturing back

Counterfactual study 1 in Developed Countries

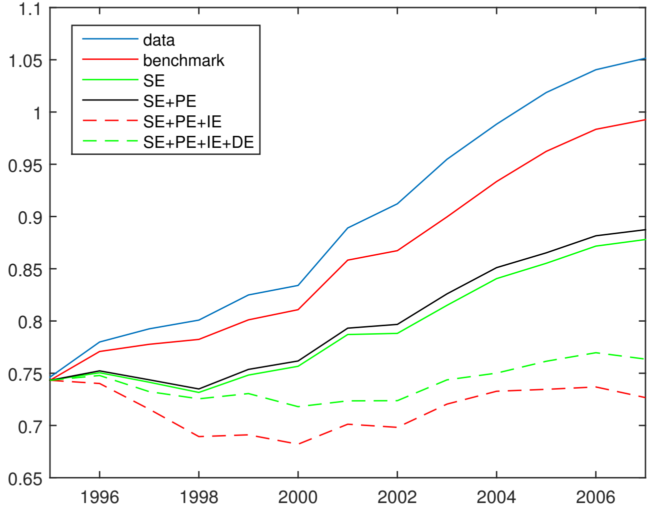

Figure: Relative VA share of MS to Manu

Counterfactual study 1 in Developing Countries

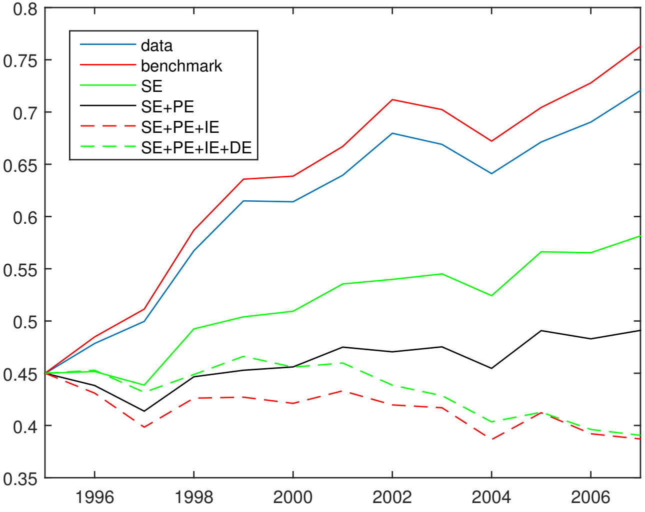

Figure: Relative VA share of MS to Manu back

CS1 in DC when $\zeta = 4; \theta = 3$

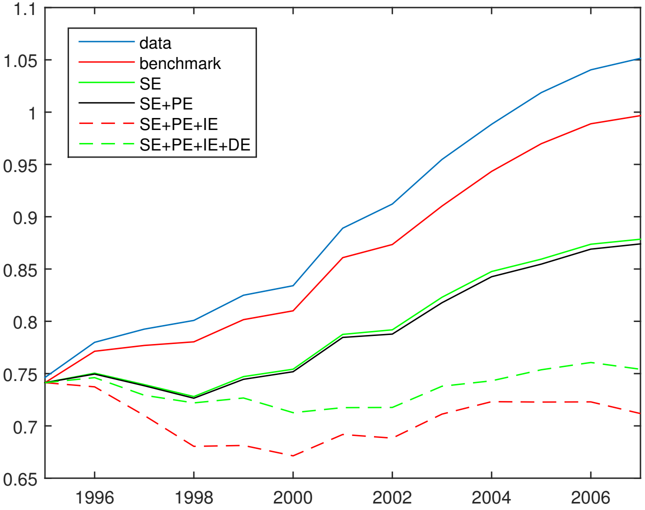

Figure: Relative VA share of MS to Manu

CS1 in DC when $\zeta = 4; \theta = 4$

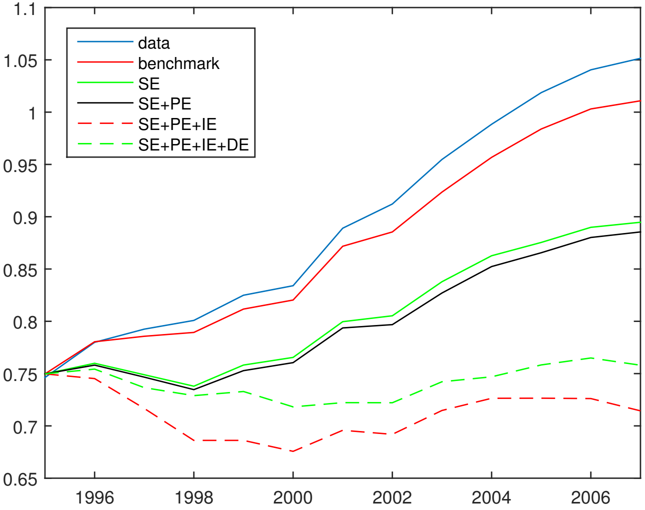

Figure: Relative VA share of MS to Manu

CS1 in DC when $\zeta = 1.2; \theta = 1.2$

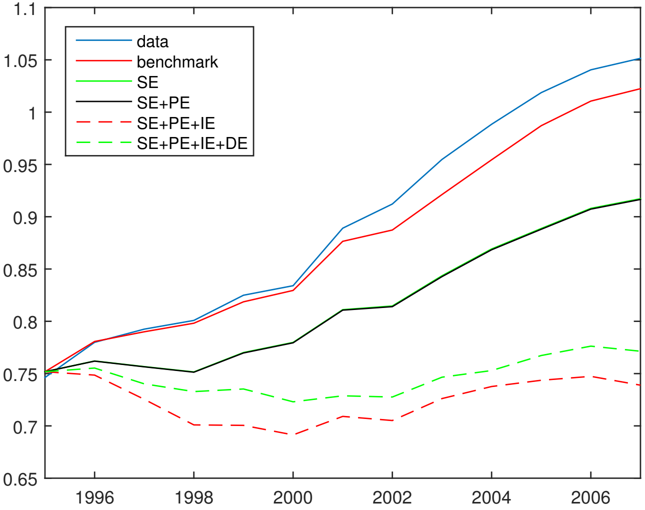

Figure: Relative VA share of MS to Manu back

Decomposition Under Counterfactual study 1

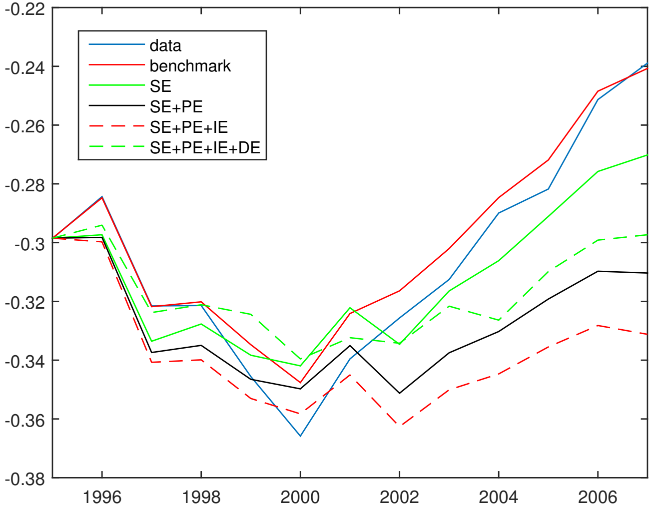

Figure: Relative VA share of OG to Manu

Decomposition Under Counterfactual study 1

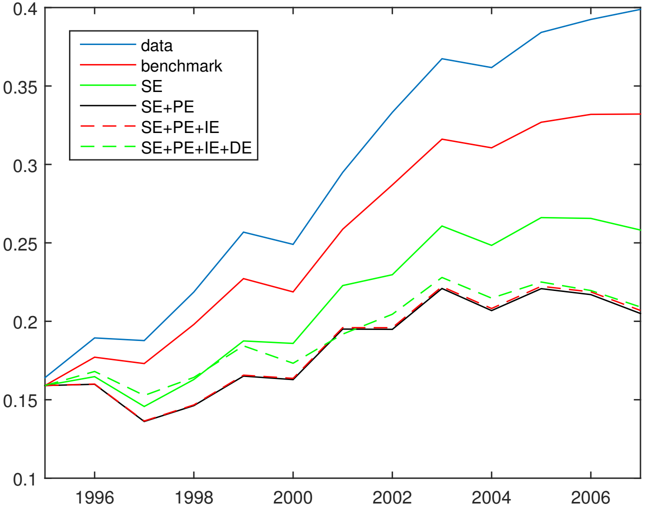

Figure: Relative VA share of NMS to Manu back

Structural Change with Employment Share

$$\log \frac{l_{it}}{l_{jt}} = \beta \log \frac{1-\sigma_{it}}{1-\sigma_{jt}} + \kappa \log \frac{\mu^s_{it}}{\mu^s_{jt}} + (1-\rho) \log \frac{P_{it}}{P_{jt}} + (\xi_i - \xi_j) \log Q_t$$

	Dependent Variable : $\log \frac{l_{it}}{l_{jt}}$						
0 **Coefficient**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
β		0.568***	0.112**	0.116***	0.264***	0.234***	0.029
		(0.079)	(0.050)	(0.043)	(0.087)	(0.050)	(0.067)
κ		0.861***	0.356***	0.160***	0.165***	0.319***	-0.065
		(0.053)	(0.042)	(0.038)	(0.037)	(0.040)	(0.063)
$1-\rho$	0.281***	0.198***	0.031	0.071**	0.066**	0.245***	0.034
	(0.034)	(0.033)	(0.033)	(0.028)	(0.028)	(0.039)	(0.040)
$\epsilon_{OG} - \epsilon_{Manu}$	0.004	0.049***	-0.080**	-0.349***	-0.341***	0.484***	-0.331***
	(0.013)	(0.012)	(0.033)	(0.061)	(0.061)	(0.064)	(0.083)
$\epsilon_{MS} - \epsilon_{Manu}$	0.031***	0.048***	0.417***	-0.080**	-0.071**	0.174***	-0.129**
	(0.009)	(0.009)	(0.023)	(0.034)	(0.034)	(0.047)	(0.061)
$\epsilon_{NMS} - \epsilon_{Manu}$	-0.023**	0.017*	0.340***	-0.274***	-0.263***	0.083	-0.320***
	(0.010)	(0.009)	(0.032)	(0.048)	(0.047)	(0.061)	(0.079)
Country FE	NO	NO	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	YES	YES	YES	YES
IS approx.	NO	NO	NO	NO	YES	NO	NO
Sample	ALL	ALL	ALL	ALL	ALL	DC	LDC

Decomposition of Employment Share

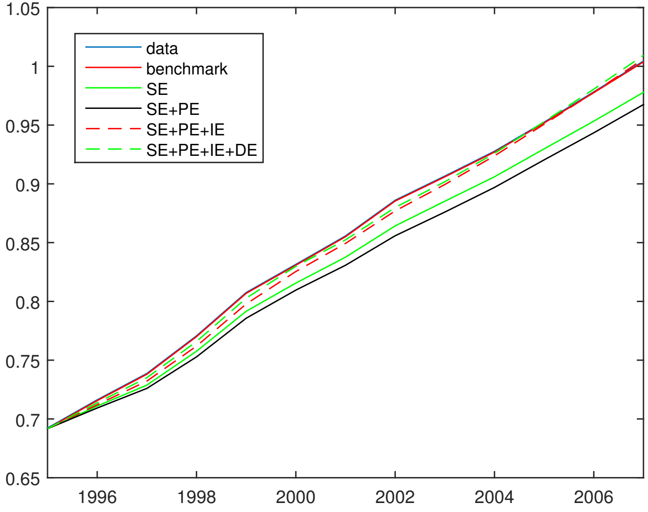

Figure: Relative Employment share of MS to Manu back

Benchmark Decomposition with $\beta = 1$

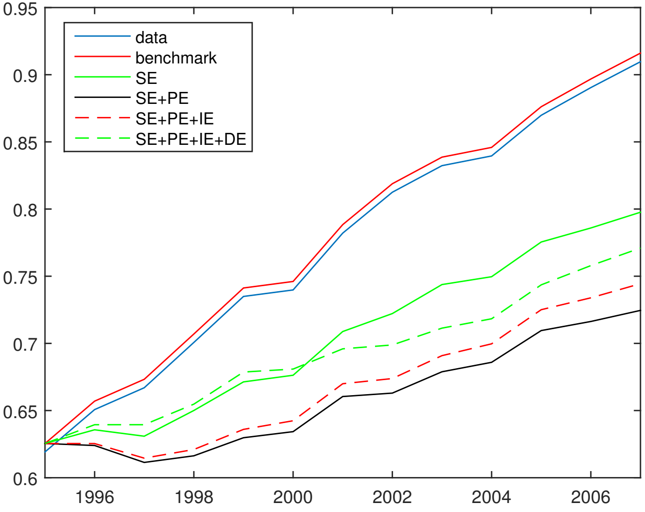

Figure: Relative VA share of MS to Manu back

Role of Outsourcing Cost

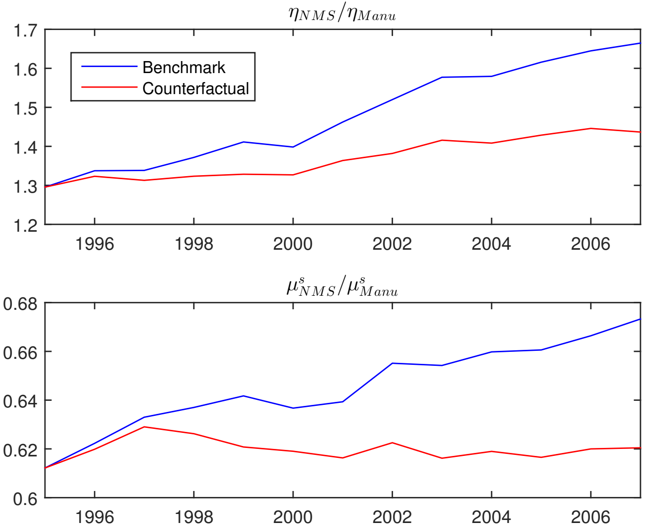

Figure: NMS to Manufacturing

Role of Outsourcing Cost

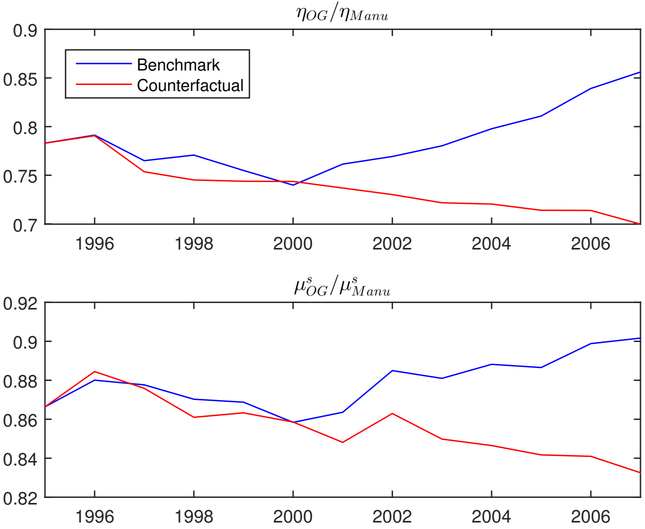

Figure: OG to Manufacturing back

Role of TFP

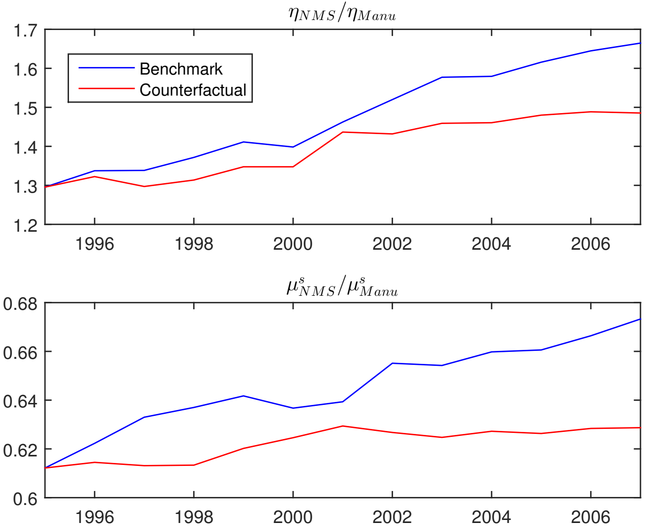

Figure: NMS to Manufacturing

Role of TFP

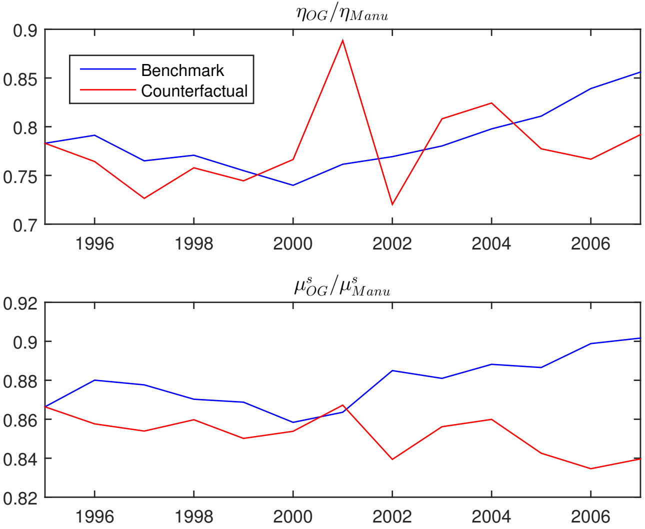

Figure: OG to Manufacturing back