Service Offshoring and White-Collar Employment

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Outline of the presentation

- Introduction and motivation
- Stylized facts
- Model
- Estimation
- Results
- Conclusions

Introduction and motivation

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- Effects on narrow occupations
- Two potential dimensions of heterogeneity

  1) Skill levels

  2) Tradeable features

- Theoretical
  1) Standard trade theories (Deardorff, 2005; Markusen, 2005; Markusen&Strand, 2007)
  2) Theory of firm's bureaucracy (Antras *et al.*, 2006a,b)
  3) Tradeable tasks (Grossman&Rossi-Hansberg, 2006)

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- Empirical
  1. Total employment (Amiti and Wei, 2005a,b)
  2. Identification of *at-risk occupations* (Bardhan&Kroll, 2003; Van Welsum&Vickery, 2005; Blinder, 2007)
     1) Routine tasks
     2) Low degrees of face-to-face contact/Impersonal services
     3) Output can be remotely transmitted

Main contribution and preview of results

- Studies the effects of service offshoring on U.S. white-collar employment, considering the two dimensions of heterogeneity *jointly*:

  1) Effects on occupations with different skill levels

  2) Effects on occupations with different tradable features

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- Results

  1) Service offshoring is skill-biased

  2) Within broadly defined skill groups, tradeable occupations are negatively affected

Data and methodology

- Occupational Employment Statistics (BLS)

  - 112 occupations (58 white-collars) - *minor occupations*
  - 13 homogeneous groups - *major groups*
  - 144 industries (9 in the service sector)
  - Time period: 1997-2002

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- Quasi-Maximum Likelihood Estimation

Service offshoring

Share of imported services on total non-energy input purchases

$$SOSS_{jt} = \frac{\sum_h \vartheta_{jh}^{97} M_{ht}}{NE_{jt}}$$

- M_{ht} = *economy-wide* imports of service h in year t
  (from BEA "U.S. International Trade in Services")
- ϑ_{jh}^{97} = share of industry j in total imports of h in 1997
  (from 1997 BEA Import Matrix)
- NE_{jt} = total purchases of non-energy inputs by industry j in year t
  (from Annual Survey of Manufactures and BEA)

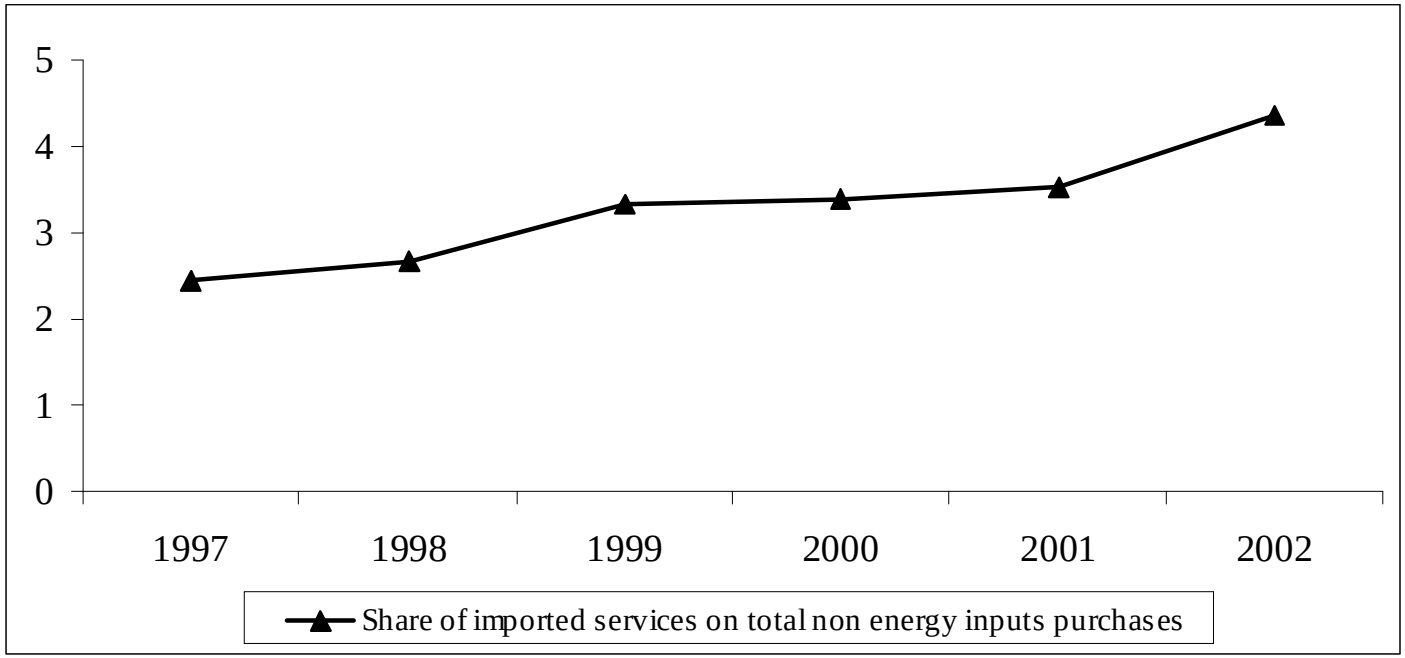
Service offshoring

Categories of Private Services Used to Compute the Proxy for Service Offshoring

Financial services
Insurance services
Computer and information services
Research, development and testing services
Business, professional and technical services
Advertising
Telecommunication
Management, consulting and public relation services
Industrial engineering
Installation, maintenance and repair of equipment
Legal services
Operational leasing
Accounting, auditing and bookkeeping
Other business, professional and technical services

Service offshoring

Unweighted averages (%)



Employment

Sample coverage

Major Occupational Group	%, 2002
White-Collars	
Management occupations	55.8
Business and financial operations occupations	54.6
Computer and mathematical occupations	59.3
Architecture and engineering occupations	76.8
Life, physical, and social science occupations	14.9
Legal occupations	75.8
Sales and related occupations	85.8
Office and administrative support occupations	54.8
Blue-Collars	
Building and grounds cleaning and maintenance occupations	14.4
Construction and extraction occupations	42.7
Installation, maintenance, and repair occupations	33.8
Production occupations	82.3
Transportation and material moving occupations	46.9

Employment changes (1997-2002)

Skill Group	%	#
High skilled	1.73	41,852
Medium skilled	-23.96	-1,067,024
Low skilled	-2.16	-389,828
Tradeable Occupation	**%**	**#**
Market and survey researchers	-53.0	-16,173
Accountants and auditors	-3.7	-21,943
Computer systems analysts	-22.1	-75,292
Computer programmers	-25.6	-104,111
Database administrators	3.8	2,113
Computer support specialists	-10.0	-29,828
Cost estimators	6.3	3,710
Statistical assistants	-35.1	-5,297
Financial clerks	6.0	82,507
Information and record clerks	-48.2	-162,233
Other off. and adm. supp. work.	-13.9	-253,106
Switchboard operators	-23.4	-22,205
Telemarketers	-52.5	-162,966

Preliminary evidence

Log-linear model

$$\ln e_{jt}^{n} = b_0 + b_1 \cdot \ln w_{jt}^{n} + b_2 \cdot SOSS_{jt} + b_3 \cdot \ln y_{jt} + \mathbf{d}'\mathbf{G}_{jt} + \varrho_{jt}$$

e = number of employees in an occupation
w = wage
y = industry output
$\mathbf{G}$ = control variables (time dummies, material offshoring, technological progress, log capital stock)

- All variables are group-mean deviated

Preliminary evidence

Log-linear model: Distribution of elasticities by skill group

	# Occupations	# Positive	# Negative
High skilled	15	11	4
Medium skilled	19	8	11
Low skilled	24	9	15

Preliminary evidence

Log-linear model: Tradeable/Non-tradeable occupations

Tradeable Occupations	Elasticity	Std. Err.	Non Tradeable Occupations	Elasticity	Std. Err.
Market and survey researchers	-0.0009	0.0062	Lawyers	0.0231	0.0104**
Accountants and auditors	-0.0039	0.0022*	Life scientists	0.0679	0.0785
Computer systems analysts	-0.0143	0.0025***	Physical scientists	0.0092	0.0089
Computer programmers	-0.0252	0.0046***	Engineering managers	0.0126	0.0064*
Database administrators	-0.0143	0.0031***	Advert. managers	0.0076	0.0032**
Computer support specialists	-0.0150	0.0031***	Computer hardware engineers	0.0248	0.0111**
Cost estimators	-0.0163	0.0039***	Management analysts	0.0150	0.0071**
Statistical assistants	-0.0265	0.0075***	Aerospace engineers	0.0095	0.0064
Financial clerks	-0.0113	0.0054**	Sales engineers	0.0057	0.0141
Information and record clerks	-0.0133	0.0062**	Mechanical engineers	0.0043	0.0111
Other off. and adm. supp. work.	-0.0121	0.0055**	Civil engineers	0.0034	0.0056
Switchboard operators	-0.0063	0.0034*	Chief executives	0.0070	0.0032**
Telemarketers	-0.0153	0.0106	Financial managers	0.0059	0.0023***
			Purchasing managers	0.0017	0.0029
			Administrative services managers	0.0101	0.0023***
			Budget analysts	0.0164	0.0045***

The model

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  1. HWS of the technology in the 13 major occupational groups

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- Implicit forms

$$C_{SR}(w_1^1, ...w_n^i, ..., w_N^I, \mathbf{p}', Y; \mathbf{z}') = C_{SR}(\chi^1, ..., \chi^i, ...\chi^I, \mathbf{p}', Y; \mathbf{z}) \quad (1)$$

where

$$\chi^i = \chi(w_1^i, ..., w_N^i; \mathbf{z}) \quad (2)$$

Homothetic wage-index for the wages of the minor occupations

Functional forms

- Flexible and Separable Translog (FAST) representation of (1) and (2)

$$
\begin{aligned}
\ln C \quad = \quad & \ln \alpha_0 + \sum_{i=1}^{I} \alpha_i \ln \chi^i + \sum_{r=1}^{R} \alpha_r \ln p_r + \alpha_Y \ln Y + \sum_{u=1}^{U} \alpha_z z_u + \\
& + \frac{1}{2} \sum_{i=1}^{I} \sum_{q=1}^{Q} \alpha_{iq} \ln \chi^i \ln \chi^q + \frac{1}{2} \sum_{r=1}^{R} \sum_{s=1}^{S} \alpha_{rs} \ln p_r \ln p_s + \\
& + \sum_{i=1}^{I} \sum_{r=1}^{R} \alpha_{ir} \ln \chi^i \ln p_r + \frac{1}{2} \alpha_{YY} (\ln Y)^2 + \frac{1}{2} \sum_{u=1}^{U} \sum_{v=1}^{V} \alpha_{zv} z_u z_v + \\
& + \sum_{u=1}^{U} \alpha_{zY} z_u \ln Y + \sum_{i=1}^{I} \alpha_{iY} \ln \chi^i \ln Y + \sum_{i=1}^{I} \sum_{u=1}^{U} \alpha_{iu} \ln \chi^i z_u + \\
& + \sum_{r=1}^{R} \alpha_{rY} \ln p_r \ln Y + \sum_{r=1}^{R} \sum_{u=1}^{U} \alpha_{ru} \ln p_r z_u \qquad (3)
\end{aligned}
$$

Functional forms

- Wage-indexes

$$\ln \chi^i = \sum_{n=1}^{N} \beta_n \ln w_n^i + \frac{1}{2} \sum_{n=1}^{N} \sum_{m=1}^{M} \beta_{nm} \ln w_n^i \ln w_m^i + \sum_{n=1}^{N} \sum_{u=1}^{U} \beta_{nu} \ln w_n^i z_u \quad (4)$$

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- Shephard's lemma applied to (3) and (4) yields $I + 1$ systems of share equations of the form:

$$S^{i(r)} = \alpha_{i(r)} + \sum_{i=1}^{I} \alpha_{iq(ir)} \ln \chi^i + \sum_{r=1}^{R} \alpha_{ir(rs)} \ln p_r + \alpha_{iY(rY)} \ln Y + \sum_{u=1}^{U} \alpha z_u \quad (5)$$

and

$$s_n^i = \beta_n + \sum_{m=1}^{M} \beta_{nm} \ln w_m^i + \sum_{u=1}^{U} \beta_{nu} z_u \quad (6)$$

Elasticities

- The labor demand elasticity of the generic n-th minor occupation to the generic u-th shift-factor is:

$$\varkappa_{n,u} = \xi^{i}_{n,u} + s^{i}_{n} \cdot \rho_{i,u} \tag{7}$$

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- For the translog

$$\xi^{i}_{n,u} = \frac{\beta_{nu}}{s^{i}_{n,jt}}$$

and

$$\begin{aligned} \rho_{i,u} \quad = \quad & \frac{a_{iu}}{S^{i}_{jt}} + \left[\left(\frac{a_{ii}}{S^{i}_{jt}} + S^{i}_{jt} - 1 \right) \cdot \left(\sum_{n=1}^{N} \beta_{nu} \ln w^{i}_{n,jt} \right) \right] + \\ & + \left[\sum_{q \neq i} \left(\frac{a_{iq}}{S^{i}_{jt}} + S^{q}_{jt} \right) \cdot \left(\sum_{n=1}^{N} \beta_{nu} \ln w^{q}_{n,jt} \right) \right] \end{aligned}$$

Estimation strategy

- The stochastic version of (5) and (6) is

$$s^i_{njt} = \beta_n + \sum_{m=1}^{M} \beta_{nm} \ln w^i_{mjt} + \sum_{u=1}^{U} \beta_{nu} z_{ujt} + \varepsilon^i_{njt} + c_j \tag{8}$$

$$\begin{aligned} S^{i(r)}_{jt} \quad = \quad & \alpha_{i(r)} + \sum_{i=1}^{I} \alpha_{iq(ir)} \ln \chi^i_{jt} + \sum_{r=1}^{R} \alpha_{ir(rs)} \ln p_{rjt} + \\ & + \alpha_{iY(rY)} \ln Y_{jt} + \sum_{u=1}^{U} \alpha_{iu(ru)} z_{ujt} + \epsilon^i_{jt} + c_j \end{aligned} \tag{9}$$

c_j = industry-specific term accounting for individual heterogeneity
ε^i_{njt} and ϵ^i_{jt} = idiosyncratic disturbances

Estimation strategy

- **Problem 1:** Censored demand systems

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  - **QMLE**: based on original work by Meyerhoefer *et al.* (2005)

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QMLE: First stage

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- The joint likelihood functions of (8) and (9) contain a NT integral
- Assume a distribution for c_j, integrate it out from the joint likelihood and use the marginals
- I use the following Correlated Random Effect (CRE) representation for c_j (Mundlak, 1978):

$$c_j = \sum_{u=1}^{U} \lambda_u \bar{z}_{ju} + \eta_j \tag{10}$$

$\bar{z}$ = group means of the shift- and quasi-fixed factors
λ_u = parameters to be estimated
η_j = projection error, uncorrelated with all the explanatory variables

Estimation strategy

QMLE: First stage

- Integrating (10) out from (8) and (9) yields:

$$s^i_{njt} = \beta_n + \sum_{n=1}^{N} \beta_{nm} \ln w^i_{njt} + \sum_{u=1}^{U} \beta_{nu} z_{ujt} + \sum_{u=1}^{U} \lambda_u \overline{z}_{ju} + v^i_{njt} \tag{11}$$

$$\begin{aligned} S^{i(r)}_{jt} \quad = \quad & \alpha_{i(r)} + \sum_{i=1}^{I} \alpha_{iq(ir)} \ln \chi^i_{jt} + \sum_{r=1}^{R} \alpha_{ir(rs)} \ln p_{rjt} + \\ & + \alpha_{iY(rY)} \ln Y_{jt} + \sum_{u=1}^{U} \alpha_{iu(ru)} z_{ujt} + \sum_{u=1}^{U} \lambda_u \overline{z}_{ju} + \varpi^i_{jt} \end{aligned} \tag{12}$$

where $\varpi^i_{jt} = \epsilon^i_{jt} + \eta_j$ and $v^i_{njt} = \varepsilon^i_{njt} + \eta_j$, with $\varpi^i_{jt} \sim N(0, \sigma^2_\varpi)$ and $v^i_{njt} \sim N(0, \sigma^2_v)$

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- The joint likelihood function of (8) and (9) has reduced to the product of N Tobit-type marginal distributions

Estimation strategy

QMLE: First stage

- The joint likelihood function of (8) and (9) has reduced to the product of N Tobit-type marginal distributions
- $\Longrightarrow$ Equation-by-equation pooled Tobit estimation of (11) and (12) yields consistent estimates of reduced form parameters

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QMLE: Second stage

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- MDE is carried out by finding the vector $\widehat{\beta}^*$ that minimizes the following quadratic form:

$$\widehat{\beta}^* = \arg\min_{\beta^*} [\widehat{\mathbf{T}} - \mathbf{H}\beta^*]' \widehat{\mathbf{W}}^{-1} [\widehat{\mathbf{T}} - \mathbf{H}\beta^*] \tag{13}$$

$\mathbf{T}$ = vector of reduced-form parameters with var-cov matrix $\mathbf{W}$
$\mathbf{H}$ = matrix of linear restrictions

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- $\widehat{\mathbf{W}}$ is constructed to correct the var-cov matrix for both serial correlation and cross-equation correlation in the scores of the likelihood function (Wooldridge, 2002)

Results

Distribution of elasticities by skill group

	# Occupations	# Positive	# Negative
High skilled	15	11	4
Medium skilled	19	8	11
Low skilled	24	8	16

Results

Service offshoring and skill level

Coefficients	Probit	Logit
High skilled	1.0537	1.7047
	[0.4584]**	[0.8882]*
Medium skilled	0.6299	1.0116
	[0.4141]	[0.7895]
Constant	-0.4307	-0.6931
	[0.2755]	[0.6285]
Marginal Effects		
High skilled	0.3853	0.3824
	[0.1430]***	[0.1712]**
Medium skilled	0.2443	0.2439
	[0.1530]	[0.1823]
Log-likelihood	-36.9070	
Pseudo-R^2	0.0812	
Observations	58	

Results

Simulated constant offshoring world

Skill Group	Implied Effect of Service Offshoring in 2002	
	%	#
High skilled	2.0	49,009
Medium skilled	-0.1	-2,863
Low skilled	-0.4	-62,176

Note: A positive number indicates that employment has been higher in 2002 than it would have been if service offshoring actually remained at the 1997 levels. Therefore, a positive number indicates that service offshoring has raised employment in the skill group.

Results

Tradeable/Non-tradeable occupations

Tradeable Occupations	$\varkappa_{n,SOSS}$	Non Tradeable Occupations	$\varkappa_{n,SOSS}$
Market and survey researchers	-0.0016	Lawyers	0.0722
Accountants and auditors	-0.0200	Life scientists	0.0201
Computer systems analysts	-0.0052	Physical scientists	0.0064
Computer programmers	-0.0252	Engineering managers	0.0195
Database administrators	-0.0066	Advert. managers	0.0023
Computer support specialists	-0.0043	Computer hardware engineers	0.0589
Cost estimators	-0.0117	Management analysts	0.0741
Statistical assistants	-0.0181	Aerospace engineers	0.0113
Financial clerks	-0.0182	Sales engineers	0.0206
Information and record clerks	-0.1501	Mechanical engineers	0.0100
Other off. and adm. supp. work.	-0.0911	Civil engineers	0.0150
Switchboard operators	-0.1544	Chief executives	0.0028
Telemarketers	-0.0009	Financial managers	0.0016
		Purchasing managers	0.0102
		Administrative services managers	0.0072
		Budget analysts	0.0002

	Crinò			BK	B	
Occupation(SOC code)	*Routine Tasks*	*Impers. Serv*	*Tradeable Output*		*Offshorability Index*	*Ranking*
Computer programmers(151021)	X	X	X	X	100	1
Telemarketers(419041)	X	X	X	X	95	2
Computer systems analysts(151051)	X	X	X	X	93	4
Computer support specialists(151041)	X	X	X	X	92	5
Market and survey researchers(193020)	X	X	X		90	6
Statistical assistants(439111)	X	X	X	X	90	6
Other office and administrative support workers(439000)	X	X	X	X	75	8
Database administrators(151061)	X	X	X	X	75	8
Financial clerks(433000)	X	X	X	X	75	8
Accountants and auditors(132011)	X	X	X	X	72	14
Information and record clerks(434000)	X	X	X	X	68	18
Cost estimators(131051)	X	X	X	X	50	27
Switchboard operators, including answering service(432011)	X	X	X	X	50	27
Drafters(173010)		X	X	X	94	3
Financial managers(113031)			X		75	8
Life scientists(191000)		X	X		75	8
Computer hardware engineers(172061)					73	13
Materials engineers(172131)			X		71	15
Mechanical engineers(172141)					70	16
Marine engineers and naval architects(172121)					69	17
Order, receptionist and information clerks(434100)	X		X	X	67	19
Physical scientists(192000)		X	X		63	20
Budget analysts(132031)		X	X	X	60	21
Engineering technicians, except drafters(173020)					57	22
Industrial production managers(113051)			X		55	23
Buyers and purchasing agents(131020)		X	X		55	23
Engineering managers(119041)					54	25
Lawyers(230000)					51	26
Administrative services managers(113011)	X		X		49	29
Human resources managers(113040)					49	29
Purchasing managers(113061)					49	29
Transportation, storage, and distribution managers(113071)					49	29
Industrial engineers(172110)					48	33
Human resources, training and labor relations specialists(131070)	X			X	46	34
Advert., MKTG, prom., P.R. and sales man.(112000)					44	35
Life, physical, and social science technicians(194000)					44	35
Material rec., sched., dispatc., and distrib. workers (435000)	X				43	37
Aerospace engineers(172011)					37	38
Weighers, measurers, checkers, and samplers, recordkeeping(435111)	X	X			27	39
Advertising sales agents(413011)	X				25	40
Chief executives(111011)			X		0	41
Construction managers(119021)					0	41
Medical and health services managers(119111)					0	41
Prop., real est., and comm.. assoc. man. (119141)					0	41
Compliance officers(131041)		X	X		0	41
Management analysts(131111)			X	X	0	41
Agricultural engineers(172021)			X		0	41
Civil engineers(172051)					0	41
Mining and geological engineers(172151)					0	41
Petroleum engineers(172171)					0	41
Cashiers, except gaming(412011)	X	X			0	41
Parts salespersons(412022)					0	41
Retail salespersons(412031)					0	41
Sales representatives(414010)		X	X		0	41
Demonstrators and product promoters(419011)	X				0	41
Sales engineers(419031)	X		X		0	41
First-line supervisors/managers of off. and admin. supp. workers(431011)				X	0	41
Executive secretaries and administrative assistants(436011)			X		0	41

Results

Tradeable/Non-tradeable occupations: Robustness checks

Classification	Crinò	Bardhan&Kroll	Blinder
High skilled	0.302**	0.321**	0.363**
	[0.137]	[0.162]	[0.150]
Medium skilled	0.195	0.217	0.282*
	[0.135]	[0.148]	[0.148]
Tradeable	-0.621***	-0.280**	-0.372**
	[0.088]	[0.142]	[0.171]
Constant	0.514***	0.450***	0.395***
	[0.110]	[0.120]	[0.105]
R^2	0.34	0.13	0.14
Obs.	58	58	58

Discussion

- Service offshoring and human capital accumulation (Trefler, 2005a,b; Mankiw&Swagel, 2006)

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- Education system (Blinder, 2006)

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- Education system (Blinder, 2006)
- Theoretical models (Markusen&Strand, 2007)

Conclusions

- This paper has studied the effects of service offshoring on U.S. white-collar employment
  1. Effects on occupations of different skill groups
  2. Effects on occupations with different tradeable features
- Two effects of service offshoring
  1. Overall employment increase in high-skilled occupations, overall employment reduction in medium- and low-skilled occupations
  2. Employment reduction in tradeable occupations, employment increase in complex and specialized non tradeable occupations