Quantifying Productivity Effects of Global Sourcing

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Research question and motivation

What is the effect of global sourcing on productivity?

- Firms organise production based on efficiency and profitability criteria. Microeconomic effects are clear.
- From a macro point of view, the answer is less clear.
- Surprisingly, and to the best of our knowledge, no one has yet addressed the issue, trying to quantify the aggregate effects of global sourcing (lack of data?).

> We focus on sourcing from Global Value Chains (GVC sourcing), i.e. importing intermediates from a GVC.

The paper in a nutshell

- We use data for 19 sectors and 34 countries for the decades '90s and '00s, combining many different sources.
- We construct (borrowing from previous contributions) measures of TFP, countries' global sourcing and sectors' production "fragmentability".
- We use Rajan and Zingales (1996) approach to identify the impact of GVC sourcing on labor productivity, TFP and employment.
- We show the impact of different GVC architectures (long vs. wide).
- We shed light on the channels through which GVC sourcing affects labour productivity and TFP (innovation vs. reallocation).

Related literature

This paper borrows from four strands of research

- GVCs: Antras *et al*. (2014), Baldwin and Venables (2013), de Backer and Miroudot (2013), Johnson and Noguera (2012), Amador and Cabral (2009), Hoen and Oosterhaven (2006).
- Production networks: Fally (2012), Nunn (2007).
- International trade: Levchenko and Zhang (2014), Finicelli *et al*. (2013), Eaton and Kortum (2002); Bloom *et al*. (2015), Bas and Strauss-Kahn (2014), Goldberg *et al*. (2013), Kasahara and Lapham (2013), Halpern *et al*. (2011), Amiti and Konings (2007), Balassa (1965).
- Growth: Rajan and Zingales (1998), Barro (1991).

Roadmap of the presentation

Global Value Chains

Definition

A **Global Value Chain** (GVC) is a directed network that connects the different phases of an *internationally fragmented* production process, i.e. such that different stages of production take place in different countries.

It can be a rather complex network

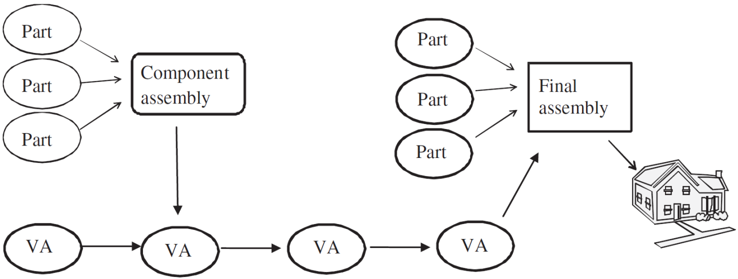


Fig. 1 in Baldwin and Venables (2013)

How important is Global Sourcing?

Note that Global Sourcing determines flows of imports and exports of intermediate goods and services between countries.

Global Sourcing is very pervasive.

Fact

$>$ 50% *of international merchandise trade is in intermediate goods.*
$>$ 70% *of international service trade is in intermediate services.*

(de Backer and Miroudot, 2013)

How can GVC sourcing increase productivity?

1. GVC sourcing can allow access to more and/or better intermediates
2. GVC sourcing can stimulate domestic competition and innovation

Outline of the empirical analysis

- We use the methodology developed by Rajan and Zingales (1996).
- Our aim is to uncover the effects of GVC sourcing (= global sourcing $\times$ GVC architecture) on *total factor productivity (TFP)*.
- Prior to this, we estimate the effect on the usual measures of labour productivity, *output per worker* and *value added per worker*.
- [We also investigate whether *total employment* is affected.]

Regression framework

We adapt Rajan and Zingales (1996) methodology to deal with **endogeneity** between *GVC sourcing* and *productivity* by uncovering the **link** between them:

$$z^s_{i,t} = \alpha + \beta N_{s,t-1} \times F_{i,t-1} + \gamma \ln Z^s_{i,t-1} + \delta \Phi^s_{i,t-1} + \theta_i + \omega_s + \varepsilon_{is}$$

where:

- $z^s_{i,t}$ is the growth rate of the relevant productivity index,
- $N_{s,t-1}$ is a measure of sectorial "fragmentability" of production,
- $F_{i,t-1}$ is a country-specific measure of global sourcing,

and $Z^s_{i,t-1}$ is the initial condition, $\Phi^s_{i,t-1}$ some control and θ_i and ω_s are country and sector fixed effects.

Data: decade averages of annual country-sector observations from 1990 to 2009.

Productivity measures

Country-Sector level

- Conventional measures of labor productivity: *real output per worker*, $\frac{Q_i^s}{L_i^s}$, and *real value added per worker*, $\frac{VA_i^s}{L_i^s}$;
- [Level of *employment*: L_i^s;]
- We want to exclude the effect coming from the services of capital and other inputs: *total factor productivity (TFP)*. Few estimates of TFP at a sufficiently fine sector-level detail and comparable across countries. We overcome this difficulty by using a model-based approach (see next slides).

A (model-based) measure of TFP

Country-Sector level

We use a model (Eaton and Kortum, 2002) based estimation of the state of technology building on Levchenko and Zhang's (2014) multi-sector extension of the methodology introduced by Finicelli *et al.* (2013).

In (very few) details, the average TFP of sector s in country i is given by

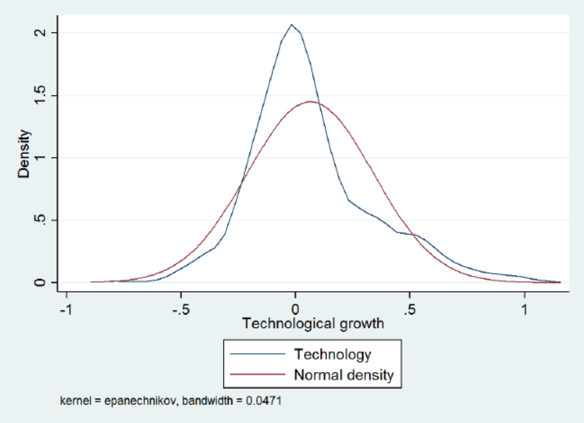
$$TFP_i^s = \left(T_i^s \times \Omega_i^s\right)^\theta$$

where:

- T_i^s is the "shifter" of the productivity distributions (Fréchet) and represents the state of technology; it can be estimated from a set of gravity equations (Levchenko and Zhang, 2014).
- $\Omega_i^s = 1 + M_i^s / (Y_i^s - X_i^s)$ is a measure of trade openness and represents the effect of resource allocation among heterogeneous firms. It is computed directly.

Estimation of T

Distribution of the estimated technological growth rates



How to measure fragmentability

Definition

Fragmentability of production is the extent to which the production process in each sector can be efficiently fragmented.

It is a technological feature of each sector's production process.

Now, a GVC is a complex network, but rather than looking for a synthetic index we focus on two key dimensions (extreme cases):

1. the vertical dimension or length (Snake-type GVC);
2. the horizontal dimension or width (Spider-type GVC).

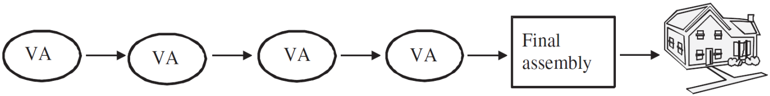
We base our measure at the I-O tables of the US, a technologically (very) advanced economy which is also relatively close w.r.t. the rest of the world.

Snake-type GVC

Definition

A *Snake* is a production network in which each node performs a stage of a sequential production process up to final assembly in the last node.

A Snake is a *line network*.



Production "Fragmentability": Snake-type GVC

Sector level

We employ the index proposed by Fally (2012), implicitly defined by:

$$N_s^{\text{Snake}} = 1 + \sum_k \mu_{s,k} N_k^{\text{Snake}}$$

where $\mu_{s,k}$ is the value of *direct inputs* from k to produce 1 dollar value of output of s. It measures the average number of stages embodied in good s, i.e. it is the weighted-average number of plants involved sequentially in the production of s.

It can be shown that $N_s^{\text{Snake}} = \sum_k v_s^{(k)} k$. The measure N_s^{Snake} is the value-added weighted average of the number of industries sequentially providing direct and indirect inputs to sector s.

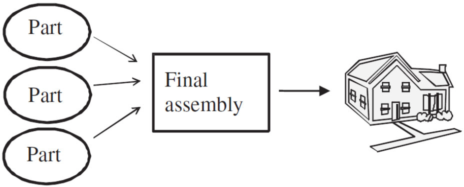
Source: 127x127 Input-Output data for the US in 1997 by the Bureau of Economic Analysis (BEA).

Spider-type GVC

Definition

A *Spider is* a production network in which each node simultaneously produces a part of the final good and ships it to the hub for final assembly.

A Spider is a *star network*.



Production "Fragmentability": Spider-type GVC

Sector level

We compute the following measure:

$$N_s^{\text{Spider}} = \sum_k \mathbf{1}_{\{\mu_{s,k} > 0\}}$$

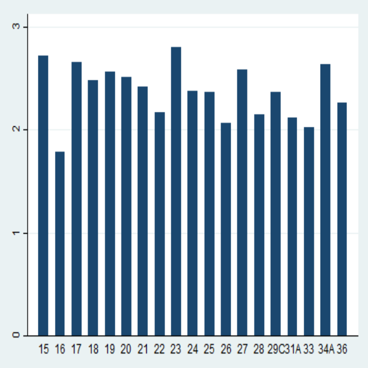
where $\mu_{s,k}$ is the value of *direct inputs* from k to produce 1 dollar value of output of s, and $\mathbf{1}_{\{\cdot\}}$ is the indicator function.

The measure N_s^{Spider} is the the number of industries directly providing inputs to sector s.

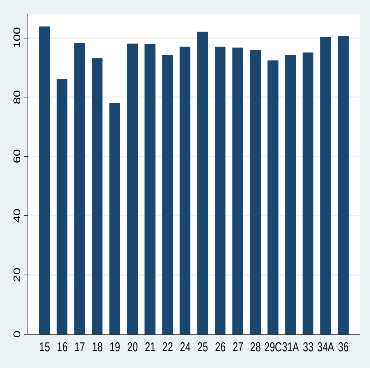
Source: 127x127 Input-Output data for the US in 1997 by the BEA.

Table: correlations with 2002

Length of Snake-type GVC



Width of Spider-type GVC



Some examples:

- Med., prec. & opt. instrum. (33): short and wide
- Tobacco prod. (16): short and narrow
- Leather, leat. prod. & footwear (19): long and narrow
- Transport. equip. (34A): long and wide

A measure of Global Sourcing

Country level

A variant of the Revealed Comparative Advantage Index (Balassa, 1965) proposed by Hoen and Oosterhaven (2006):

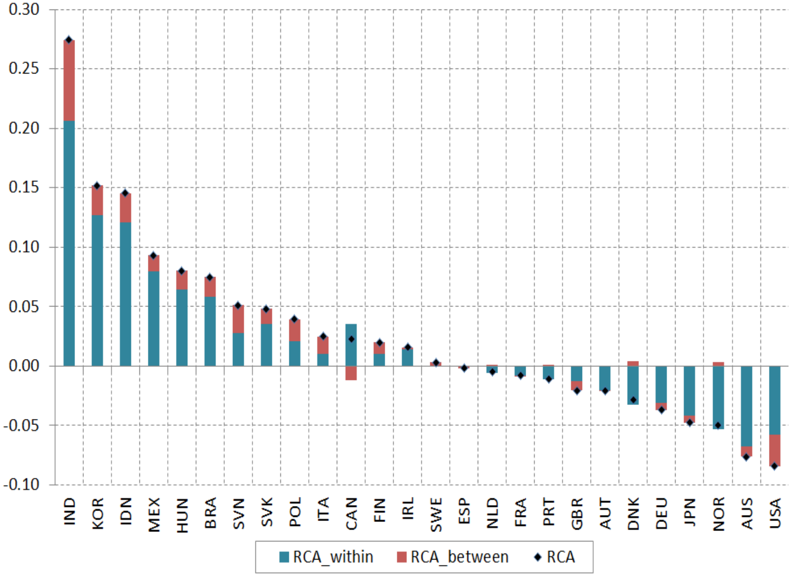
$$RCA_{i,t} = M_{i,t}^{\mathrm{Int}} \Big/ M_{i,t}^{\mathrm{Tot}} - \sum_{j \in N} M_{j,t}^{\mathrm{Int}} \Bigg/ \sum_{j \in N} M_{j,t}^{\mathrm{Tot}}$$

which can be decomposed in a **within-** and a **between-sector component**. The relevant term is the within component which accounts for differences within sectors across countries.

$$RCA_{i,t}^{\mathrm{W}} = \frac{1}{2} \sum_{s} \left(\frac{x_{i,s}^{\mathrm{Int}}}{x_{i,s}^{\mathrm{Tot}}} - \frac{x_{W,s}^{\mathrm{Int}}}{x_{W,s}^{\mathrm{Tot}}} \right) \left(\frac{x_{i,s}^{\mathrm{Tot}}}{\sum_s x_{i,s}^{\mathrm{Tot}}} + \frac{x_{W,s}^{\mathrm{Tot}}}{\sum_s x_{W,s}^{\mathrm{Tot}}} \right)$$

Source: OECD Bilateral Trade in Goods by Industry and End- use Category data on manufacturing trade, excluding energy and non-energy raw materials.

The *RCA* Indices



Regression outline

Recall our key equation:

$$z^s_{i,t} = \alpha + \beta N_{s,t-1} \times F_{i,t-1} + \gamma \ln Z^s_{i,t-1} + \delta \Phi^s_{i,t-1} + \theta_i + \omega_s + \varepsilon_{is}$$

We use:

- 6 productivity indices: $\frac{Q^s_i}{L^s_i}$, $\frac{VA^s_i}{L^s_i}$, L^s_i, TFP^s_i, T^s_i and Ω^s_i;
- 2 measures of fragmentability of production: N^{Snake}_s and N^{Spider}_s
- 2 measures of global sourcing: $RCA_{i,t}$ and $RCA^{\mathrm{W}}_{i,t}$

The Data

Sources:

- **International Trade**: OECD BTDIxE (RCA indices); UNIDO Industrial Demand-Supply Balance Database (Ω, TFP); UN Comtrade (T, TFP).
- **Production**: BEA Make and Use Tables (N^{Snake}, N^{Spider}); UNIDO Industrial Statistics Database (Q, VA, L); OECD Main Economic Indicators (Q, VA); IMF International Financial Statistics (Q, VA); Levchenko and Zhang (2013) (T, TFP); NBER-CES Manufacturing Industry Database (T, TFP).

Sample:

- we restrict the sample by intersecting all available samples and removing outliers ($> 3\sigma$) for each dependent variable;
- 26 countries ▸ List of countries
- 19 sectors ▸ Table: sectors

▸ Table: summary statistics

Effects of Import Specialization in Intermediates I

Table: Snake-type GVCs and "within-sector" RCA

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta ln\frac{Q}{L}$	$\Delta ln\frac{VA}{L}$	ΔlnL	ΔlnTFP	ΔlnT	$\Delta ln\Omega$
$N^{Snake}\times$	1.51**	1.28**	-0.09	0.61**	0.45**	-0.19
RCA	(0.59)	(0.62)	(0.91)	(0.28)	(0.20)	(0.14)
$VAshare_{90}$	0.18	-0.10	-0.22	0.43***	0.66***	-0.48***
	(0.53)	(0.56)	(0.63)	(0.13)	(0.15)	(0.12)
$Depend_{90}$	-0.09*	-0.14**	-0.01	-0.42***	-0.24***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
Constant	1.52**	2.13***	-0.27	0.68***	0.42***	0.03***
	(0.69)	(0.71)	(0.35)	(0.10)	(0.10)	(0.01)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table: Snake and full RCA

Effects of Import Specialization in Intermediates II

Table: Spider-type GVCs and "within-sector" RCA

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta ln \frac{Q}{L}$	$\Delta ln \frac{VA}{L}$	ΔlnL	ΔlnTFP	ΔlnT	$\Delta ln\Omega$
$ln(N^{Spider}) \times$	9.93***	9.34***	-8.76**	2.09**	0.57	1.15**
RCA	(2.27)	(2.19)	(3.81)	(0.77)	(0.66)	(0.44)
$VAshare_{90}$	0.30	0.01	-0.01	0.46***	0.66***	-0.47***
	(0.51)	(0.53)	(0.60)	(0.12)	(0.15)	(0.12)
$Depend_{90}$	-0.09*	-0.14**	-0.03	-0.41***	-0.23***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
Constant	0.83	1.46**	0.60	0.52***	0.37***	-0.06*
	(0.68)	(0.71)	(0.52)	(0.11)	(0.12)	(0.03)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

▸ Table: Spider and full RCA ▸ Table: Snake and Spider together

Estimation results in a nutshell

Summing up the estimation results:

- **Output per worker** is affected both by Snake- and Spider-type GVCs.
- **Value added per worker** is affected both by Snake- and Spider-type GVCs.
- **Employment** is affected by Spider-type GVCs **only**.
- **TFP** is affected both by Snake- and Spider-type GVCs.
- **T** is affected by Snake-type GVCs **only**.
- Ω is affected by Spider-type GVCs **only**.

Concluding Remarks

- ★ We use variations of "fragmentability" across sectors and of propensity to intermediate imports to assess the effect of GVC sourcing on productivity.
- ★ We uncover an strong impact of GVC sourcing on labour productivity and TFP.
- ★ The different architectures of GVCs (Snake vs. Spider) impact TFP via different channels (technological change and resource reallocation, respectively).

Thank you for your attention!

Estimation of state of technology parameter

We estimate a production function for each sector of the US economy:

$$\begin{aligned} lnY_{US}^{s} &= \ln TFP_{US}^{s} + \alpha^{s}\beta^{s} lnL_{US}^{s} + (1-\alpha^{s})\beta^{s} lnK_{US}^{s} + \\ &+ (1-\beta^{s})\sum_{k}\gamma_{ks} lnM_{US}^{ks} \end{aligned}$$

and recover $T_{US}^{s}$from TFP_{US}^{s}

$$T_{US}^{s} = \frac{\left(TFP_{US}^{s}\right)^{\theta}}{\underbrace{1 + M_{US}^{s} / \left(Y_{US}^{s} - X_{US}^{s}\right)}_{\Omega_{US}^{s}}}$$

We then use $\frac{T_{i}^{s}}{T_{US}^{s}}$ kindly provided by Levchenko and Zhang (2014) to retrieve all T_{i}^{s}.

TFP

Table: Measures of Fragmentability - Correlations

	N_{1997}^{Snake}	N_{1997}^{Spider}	N_{2002}^{Snake}	N_{2002}^{Spider}
N_{1997}^{Snake}	1.00	-	-	-
N_{1997}^{Spider}	0.38	1.00	-	-
NN_{2002}^{Snake}	0.94	0.61	1.00	-
N_{2002}^{Spider}	0.32	0.90	0.52	1.00

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Country list

Australia (AUS), Austria (AUT), Brazil (BRA), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Hungary (HUN), India (IND), Indonesia (IDN), Ireland (IRL), Italy (ITA), Japan (JPN), Mexico (MEX), Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Slovakia (SVK), Slovenia (SVN), South Korea (KOR), Spain (ESP), Sweden (SWE), United Kingdom (GBR), and United States (USA).

▸ The data

Table: Manufacturing sectors: $ISIC_{LVK}$ code and description

15	Food and Beverages
16	Tobacco Products
17	Textiles
18	Wearing Apparel, Fur
19	Leather, Leather Products, Footwear
20	Wood Products (excluding Furniture)
21	Paper and Paper Products
22	Printing and Publishing
23	Coke, Refined Petroleum Products, Nuclear Fuel
24	Chemical and Chemical Products
25	Rubber and Plastics Products
26	Non-Metallic Mineral Products
27	Basic Metals
28	Fabricated Metal Products
29C	Office, Accounting, Computing, and Other Machinery
31A	Electrical Machinery, Communication Equipment
33	Medical, Precision, and Optical Instruments
34A	Transport Equipment
36	Furniture and Other Manufacturing

▸ The data

Table: Summary statistics

Variable	n. obs	Mean	Std. Dev.	Min	Max
$\Delta ln\left(\frac{Q^s_{i,t}}{L^s_{i,90}}\right)$	597	.207	.332	-.891	1.383
$\Delta ln\left(\frac{VA^s_{i,t}}{L^s_{i,90}}\right)$	599	.103	.341	-1.017	1.146
$\Delta lnL^s_{i,t}$	820	10.139	1.858	3.816	14.412
$\Delta lnT^s_{i,t}$	811	.074	.286	-.751	1.105
N^{Snake}_s	811	2.326	.234	1.784	2.695
$RCA(\mathrm{imp})_{i,90}$	811	1.021	.161	.768	1.453

▸ The data

Effects of Import Specialization in Intermediates III

Table: Snake-type GVCs and RCA

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta ln \frac{Q}{L}$	$\Delta ln \frac{VA}{L}$	ΔlnL	ΔlnTFP	ΔlnT	$\Delta ln\Omega$
$N^{Snake} \times$	1.20**	1.05**	0.05	0.48**	0.31*	-0.14
RCA	(0.45)	(0.51)	(0.72)	(0.22)	(0.17)	(0.11)
$VAshare_{90}$	0.19	-0.09	-0.22	0.43***	0.66***	-0.48***
	(0.53)	(0.56)	(0.64)	(0.13)	(0.15)	(0.12)
$Depend_{90}$	-0.09*	-0.14**	-0.01	-0.42***	-0.24***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
Constant	1.51**	2.13***	-0.27	0.68***	0.42***	0.03***
	(0.68)	(0.71)	(0.35)	(0.10)	(0.10)	(0.01)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Effects of Import Specialization in Intermediates IV

Table: Spider-type GVCs and RCA

	(1) $\Delta ln\frac{Q}{L}$	(2) $\Delta ln\frac{VA}{L}$	(3) ΔlnL	(4) ΔlnTFP	(5) ΔlnT	(6) $\Delta ln\Omega$
$ln(N^{Spider})\times$	8.06***	7.95***	-6.95**	1.62**	0.37	0.87**
RCA	(1.92)	(1.89)	(2.87)	(0.63)	(0.55)	(0.34)
$VAshare_{90}$	0.31	0.03	-0.01	0.46***	0.66***	-0.47***
	(0.51)	(0.53)	(0.61)	(0.12)	(0.15)	(0.12)
$Depend_{90}$	-0.09*	-0.15**	-0.030	-0.41***	-0.23***	-0.52***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
Constant	0.69	1.28*	0.74	0.50***	0.37***	-0.07*
	(0.68)	(0.71)	(0.55)	(0.12)	(0.13)	(0.04)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Effects of Import Specialization in Intermediates V

Table: Snake and spider-type GVCs and "within-sector" RCA in intermediates

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta ln \frac{Q}{L}$	$\Delta ln \frac{VA}{L}$	ΔlnL	ΔlnTFP	ΔlnT	$\Delta ln\Omega$
$N^{Snake} \times$	0.89	0.66	0.61	0.49*	0.44**	-0.31*
RCA	(0.59)	(0.57)	(0.90)	(0.25)	(0.20)	(0.15)
$ln(N^{Spider}) \times$	8.94***	8.58***	-9.51**	1.54***	0.08	1.52***
RCA	(2.21)	(2.08)	(4.10)	(0.55)	(0.59)	(0.55)
$VAshare_{90s}$	0.27	-0.01	-0.00	0.45***	0.66***	-0.47***
	(0.51)	(0.53)	(0.61)	(0.13)	(0.15)	(0.12)
$Depend_{90s}$	-0.10*	-0.15**	-0.03	-0.42***	-0.24***	-0.53***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.07)	(0.11)
Constant	0.95	1.52**	0.66	0.56***	0.42***	-0.09**
	(0.67)	(0.70)	(0.53)	(0.10)	(0.11)	(0.04)
N	546	546	546	501	546	501

All regressions include country and sector fixed effects. Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. back