Multinational Firms and International Business Cycle Transmission

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Do multinational firms contribute to international comovement?

- International business cycle comovement: significant and not fully-understood
  - Potentially large role of multinationals
    - Produce about 0.25 of world output
    - Can transfer technology across countries
    - Vertical production linkages
  - Hard to quantify

- This paper: New data and model to shed light on this question
I- New data and facts on comovement within multinationals

Data:
- Firm level data from ORBIS, cross- and within-border ownership
- Parents and foreign affiliates observed in the same dataset
- 8 Million firms, 34 countries, 2004-2012

Findings:
1. Firm-level: strong correlation between parents and affiliates growth
   - Elasticity of affiliate to parent growth \( \simeq 20\% \)

2. Source-destination level: decompose growth rates into source and destination effects
   - Source effects explain 10% of variation in the data (to 20% for destination effects)
II- Quantitative model to evaluate aggregate implications

1. Embed observed comovements into quantitative MP framework
   - Multinationals transmit technology shocks across countries
   - Shocks originated in the source country are important for affiliates’ productivity $\approx 20 – 40\%$

2. Measure contribution of multinationals to aggregate comovements
   - Transmission of shocks:
     - Aggregate: about 10%
     - Largest source countries: 1-2%
     - Other source countries: almost nil

   - Bilateral business cycle correlation due to multinationals:
     - Only 0.01 if shocks are uncorrelated
     - Slope wrt multinational shares $\approx 1/4$ that in the data

   - Counterfactual std. in growth rates:
     - Without multinationals: 10% larger
     - Complete integration: 35% lower
Related Literature

- **Multinationals in the international business cycle** [Burstein et al. (2008); Contessi (2010); Zlate (2012); Kose and Yi (2001); Arkolakis and Ramanarayanan (2009); Johnson (2013)]
  - Contribution: Multicountry-framework, calibrated to microdata on parent-affiliate comovement

- **Empirics on multinationals and comovement** [Budd et al., 2005; Desai and Foley, 2006; Desai et al., 2009; Buch and Lipponer (2005); Kleinert et al. (2012)]
  - Contribution: firm-level data from multiple countries, focus on output comovement

- **Multinationals and technology transfers** [McGrattan and Prescott (2009, 2010); Burstein and Monge-Naranjo (2009); Keller and Yeaple (2013); Ramondo and Rodríguez-Clare (2013); Ramondo (2014); Alvarez (2013); Fons Rosen et al. (2013) etc.]
  - Contribution: Estimate transmission at business cycle frequency
Data

- ORBIS (Bureau van Dijk)
- Data from business registries and annual reports
- Both publicly listed and private firms
- Manufacturing and non-manufacturing
- 2004-2012
- Cross-firm ownership data
  - Multinationals >50% ownership
Data summary

- Sample: 34 countries with good coverage
  - Europe (Euro Area and periphery) + AUS, JPN, KOR, MEX, SGP
  - Average country: 180K firms

- Foreign multinationals account for a large share of revenue
  - 1/4 in our median country, >1/2 in some countries

- Large share of revenues concentrated in a few multinationals
  - In the median country, 5 largest foreign multinationals account for 5% of revenues
Affiliate-parent correlations

\[ \gamma_{in,t}(f) = \phi \gamma_{ii,t}(f) + \bar{a}_{inss',t} + \epsilon_{in,t}(f) \]

- \( \gamma_{in,t}(f) \): revenue growth rate of firm \( f \)
  - source \( i \), destination \( n \)

- \( \gamma_{ii,t}(f) \): growth rate of parent in \( i \)

- \( \bar{a}_{inss',t} \): source \( \times \) sector \( \times \) destination \( \times \) sector \( \times \) year FE

- Sample: run on affiliates only
### Affiliate-parent correlations

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Manufacturing</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi )</td>
<td>0.278*** (0.00524)</td>
<td>0.402*** (0.0137)</td>
<td>0.233*** (0.00628)</td>
</tr>
<tr>
<td></td>
<td>0.228*** (0.0117)</td>
<td>0.299*** (0.0394)</td>
<td>0.213*** (0.0131)</td>
</tr>
<tr>
<td>Obs.</td>
<td>181978</td>
<td>19756</td>
<td>105774</td>
</tr>
<tr>
<td>N. mult.</td>
<td>18881</td>
<td>2470</td>
<td>12419</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.047</td>
<td>0.102</td>
<td>0.032</td>
</tr>
<tr>
<td>FE</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

SE clustered at the parent level

- Strong positive correlation between affiliates and parents
- Larger effects in manufacturing
- Robustness: FE, aggregation, alternative samples, growth in VA
Bilateral comovements

\[ \gamma_{in,t} = s_{i,t} + d_{n,t} + a_{in,t} \]

- \( \gamma_{in,t} \): growth rate of combined sales of firms from \( i \) operating in \( n \)
- \( s_{i,t} \): source effect, common to all sales of firms from \( i \) worldwide
- \( d_{n,t} \): destination effect, common to all sales in \( n \)
## Bilateral comovements

<table>
<thead>
<tr>
<th>Year-by-year (2005-2012)</th>
<th>Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.10</td>
<td>2.54</td>
</tr>
<tr>
<td>Median</td>
<td>0.09</td>
<td>2.28</td>
</tr>
</tbody>
</table>

Pooled + in FE

<table>
<thead>
<tr>
<th>Year-by-year (2005-2012)</th>
<th>Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.10</td>
<td>6.82</td>
</tr>
</tbody>
</table>
Model

- Multi-country structure
  - Homogeneous final good, produced with multiple intermediate goods

- Multinationals and domestic firms produce intermediate goods
  - Productivity of multinationals affiliates responds to shocks in source and destination
  - Aggregate productivity driven by productivity of all firms within the country

- Focus on output and productivity
  - Implications independent of international asset markets and demand shocks
Technologies and preferences

- Output of firm \( f \):

\[
Q_{in,t}(f) = Z_{in,t}(f) L_{in,t}(f) = Z_{i,t}(f) Z_{n,t}^{1-\phi}(f) L_{in,t}(f)
\]

- Freely traded final good (\( P_t^W = P_{n,t} = 1 \))

\[
Q_{n,t} = \left[ \sum_i \sum_{f \in \Omega_i} A_{in,t}^{\frac{1}{\rho}} Q_{in,t}(f) \frac{\rho - 1}{\rho} \right]^{\frac{\rho}{\rho - 1}}
\]

- Labor supply (GHH preferences)

\[
L_{n,t} = W_{n,t}^{\psi - 1}
\]
Equilibrium

- Real wage

\[ W_{n,t} = \frac{\rho - 1}{\rho} \left[ \sum_i \sum_{f \in \Omega_i} A_{in,t} Z_{in,t}(f)^{\rho - 1} \right]^{1/\rho - 1} \]

- Aggregate revenues:

\[ \sum_i P_{in,t} Q_{in,t} = Q_{n,t} = \frac{\rho}{\rho - 1} W_{n,t} L_{n,t} \]

- Aggregate output:

\[ Q_{n,t} = \bar{\rho} \left[ \sum_i \sum_{f \in \Omega_i} A_{in,t} Z_{in,t}(f)^{\rho - 1} \right]^{\psi/\rho - 1} \]
Aggregate growth rate

Revenue growth:

\[ \gamma_{n,t} = \psi \sum_i \sum_{f \in \Omega_i} \omega_{in,t}(f) \left[ \frac{a_{in,t}}{\rho - 1} + \phi z_{i,t}(f) + (1 - \phi) z_{n,t}(f) \right] \]

where \( \omega_{in,t}(f) \) is firm \( f \)'s revenue share.

Special case: \( z_{n,t}(f) = z_{n,t} \)

\[ \gamma_{n,t} = \psi \sum_i \omega_{in,t} \left[ \frac{a_{in,t}}{\rho - 1} + \phi z_{i,t} \right] + \psi (1 - \phi) z_{n,t} \]

where, \( z_{i,t} = \sum_{f \in \Omega_i} \frac{\omega_{in,t}(f)}{\omega_{in,t}} z_{i,t}(f) \)
Affiliate-parent comovements

- Firm $f$ revenue growth in destinations $n$ and $i$:

$$
\gamma_{in,t}(f) = \bar{a}_{in,t} + (\rho - 1) \phi z_{i,t}(f) + (\rho - 1)(1 - \phi) z_{n,t}(f)
$$

$$
\gamma_{ii,t}(f) = \bar{a}_{ii,t} + (\rho - 1) z_{i,t}(f)
$$

- Substituting:

$$
\gamma_{in,t}(f) = \tilde{a}_{in,t} + \phi \gamma_{ii,t}(f) + \varepsilon_{in,t}(f)
$$

where $\bar{a}_{in,t} \equiv \tilde{a}_{in,t} - \phi \tilde{a}_{ii,t}$ and $\varepsilon_{in,t}(f) \equiv (\rho - 1)(1 - \phi) z_{n,t}(f)$

- Conclusion: $\phi \approx 0.2$
Calibrating $\phi$ with bilateral data

- Under $z_{n,t}(f) = z_{n,t}$ bilateral sales growth is:

\[ \gamma_{in,t} = s_{i,t} + d_{n,t} + a_{in,t} \]

With

- $s_{i,t} = \phi (\rho - 1) z_{i,t}$
- $d_{n,t} = \frac{\psi + 1 - \rho}{\rho - 1} \sum_i \omega_{in,t} [a_{in,t} + \phi (\rho - 1) z_{i,t}] + \psi (1 - \phi) z_{n,t}$

- Low $\phi$ implies small source effects, and large destination effects
  - Choose $\phi$ to match relative variance of source and destination effects
- Conclusion: $\phi \approx 0.4$
Transmission of shocks across countries

Q: How does the UK respond to a shock that increases US output by 1%?

Elasticity of growth in $n$ to a shock in $i$

$$\frac{\partial \gamma_n}{\partial z_i} = \psi [\omega_{in} \phi + (1 - \phi) \mathbb{I}_{i=n}]$$

Relative to $i$:

$$\frac{\partial \gamma_n}{\partial z_i} / \frac{\partial \gamma_i}{\partial z_i} = \frac{\omega_{in} \phi}{\omega_{ii} \phi + (1 - \phi)} \quad n \neq i.$$
Response to shock that increases source country GDP by 1%
Response to shock that increases source country GDP by 1%
Q: what would be the combined impact of a shock to all multinationals operating in the country?

Change in productivity will be:

\[ \phi (1 - \omega_{nn}) \]
Combined impact of all multinational activity

\[ \phi(1 - \omega_{nn}) \]
Growth correlations

<table>
<thead>
<tr>
<th>$\rho_{n,n'}$</th>
<th>Mean</th>
<th>St.Dev.</th>
<th>Min</th>
<th>Max</th>
<th>$d\rho_{n,n'}/d\omega$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>0.18</td>
<td>0.35</td>
<td>-0.68</td>
<td>0.87</td>
<td>2.27</td>
</tr>
<tr>
<td>Model</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.25</td>
<td>0.54</td>
</tr>
</tbody>
</table>

- max: US-Ireland (0.25), US-UK (0.12), US-Netherlands (0.12)
- 95% of country-pairs under 0.03
Counterfactual growth rates

Aggregate growth rate:

\[ \gamma_{n,t} = \psi \sum_i \omega_{in,t} \left[ \frac{a_{in,t}}{\rho - 1} + \phi z_{i,t} \right] + \psi (1 - \phi) z_{n,t} \]

Two counterfactuals, changing multinational shares:

1. “No multinationals:” \( \omega^{NM}_{in,t} = 1 \) if \( i = n \), \( \omega^{NM}_{in,t} = 0 \) if \( i \neq n \)
2. “Full Integration:” \( \omega^{FI}_{in,t} = \bar{\omega}^{FI}_{i,t} = \frac{1}{N} \sum_n \omega_{in,t} \)

- Focus on \( \sigma_{\gamma_n} \)
Counterfactual dispersion in growth rates

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>No Multinationals</th>
<th>Full Integration</th>
<th>C1/Model</th>
<th>C2/Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2005-2012</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.058</td>
<td>0.064</td>
<td>0.039</td>
<td>1.094</td>
<td>0.673</td>
</tr>
<tr>
<td>Median</td>
<td>0.060</td>
<td>0.066</td>
<td>0.039</td>
<td>1.087</td>
<td>0.654</td>
</tr>
</tbody>
</table>
Taking stock

1. Documented strong comovements between parent’s and their foreign affiliates $\simeq 20 - 40\%$

2. Limited contribution of multinationals for observed comovements
   - Small bilateral MP shares
   - Important for some country pairs (i.e. involving the US)

3. Can become an important channel as MP shares grow (i.e. counterfactual full integration)
Firm level

Q: How does Ireland respond to a firm-level shock to that increases US output by 1%?

Elasticity of growth in $n$ to a shock in $i$

$$\frac{\partial \gamma_n}{\partial z_i(f)} = \psi \omega_{in}(f) [\phi + (1 - \phi) \mathbb{I}_{i=n}]$$

Relative to $i$:

$$\frac{\frac{\partial \gamma_n}{\partial z_i(f)}}{\frac{\partial \gamma_i}{\partial z_i(f)}} = \frac{\omega_{in}(f) \phi}{\omega_{ii}(f) [\phi + (1 - \phi) I_{i=n}]} \quad n \neq i.$$
Response to firm-shock that increases source country GDP by 1%
Preferences

- Utility:

\[
u(C_{n,t}, L_{n,t}) = \sum_t \delta^t v \left( C_{n,t} - \frac{\psi_0}{\bar{\psi}} L_{n,t} \right)
\]

- Labor supply:

\[
L_{n,t} = \left[ \frac{W_{n,t}}{P_t^W} \right]^{\frac{1}{\psi-1}}
\]

- where \( W_{n,t} \) is the wage.
# Affiliate-parent correlations

<table>
<thead>
<tr>
<th></th>
<th>(1) Parent-affiliate in the same service sub-sector</th>
<th>(2) Services, excluding wholesale trade</th>
<th>(3) Services, excluding retail trade</th>
<th>(4) Excluding NDL and IRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>0.191***</td>
<td>0.179***</td>
<td>0.225***</td>
<td>0.228***</td>
</tr>
<tr>
<td></td>
<td>(0.0201)</td>
<td>(0.0205)</td>
<td>(0.0123)</td>
<td>(0.0118)</td>
</tr>
<tr>
<td>Obs.</td>
<td>73856</td>
<td>111795</td>
<td>169790</td>
<td>170135</td>
</tr>
<tr>
<td>N. mult.</td>
<td>7095</td>
<td>12824</td>
<td>17270</td>
<td>18173</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.746</td>
<td>0.829</td>
<td>0.727</td>
<td>0.717</td>
</tr>
</tbody>
</table>
Affiliate-parent correlations

<table>
<thead>
<tr>
<th></th>
<th>(5) Excluding crisis years (2008-2012)</th>
<th>(6) Small affiliates only</th>
<th>(7) Value added</th>
<th>(8) Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>0.179***</td>
<td>0.276***</td>
<td>0.140***</td>
<td>-0.0134</td>
</tr>
<tr>
<td></td>
<td>(0.0209)</td>
<td>(0.0264)</td>
<td>(0.0163)</td>
<td>(0.00891)</td>
</tr>
<tr>
<td>Obs.</td>
<td>55796</td>
<td>79626</td>
<td>68627</td>
<td>181978</td>
</tr>
<tr>
<td>N. mult.</td>
<td>10953</td>
<td>9013</td>
<td>7594</td>
<td>18881</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.720</td>
<td>0.797</td>
<td>0.733</td>
<td>0.711</td>
</tr>
</tbody>
</table>
Largest firms

- Large share of revenues concentrated in a few multinationals
Estimating $\phi$ with bilateral data

$\phi$ enters relationship between source and destination shocks

$$d_{n,t} = \left[ \frac{\psi}{\rho - 1} - 1 \right] \sum_i \omega_{in,t} [a_{in,t} + s_{i,t}] + \frac{\psi}{\rho - 1} \frac{1 - \phi}{\phi} s_{n,t}$$

We can write:

$$\phi = \frac{\sigma_{s,t}}{\sigma_{s,t} + \sigma_{\Phi_t}}$$

$\sigma_{\Phi_t}$ combines destination and GE effects. $\sigma_{\Phi_t} = \sigma_{d,t}$ in special case of $\psi = \rho - 1$

Intuition: $\phi$ is related to the variance of the source and destination effects. Low $\phi$ means small source effects, and large destination effects.
Estimating $\phi$ with bilateral data

<table>
<thead>
<tr>
<th>Year</th>
<th>$\frac{\psi}{\rho-1} = 1$</th>
<th>$\frac{\psi}{\rho-1} = 2$</th>
<th>$\frac{\psi}{\rho-1} = \frac{2}{3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.470</td>
<td>0.552</td>
<td>0.375</td>
</tr>
<tr>
<td>2006</td>
<td>0.449</td>
<td>0.531</td>
<td>0.373</td>
</tr>
<tr>
<td>2007</td>
<td>0.390</td>
<td>0.472</td>
<td>0.319</td>
</tr>
<tr>
<td>2008</td>
<td>0.373</td>
<td>0.482</td>
<td>0.286</td>
</tr>
<tr>
<td>2009</td>
<td>0.395</td>
<td>0.532</td>
<td>0.294</td>
</tr>
<tr>
<td>2010</td>
<td>0.400</td>
<td>0.518</td>
<td>0.308</td>
</tr>
<tr>
<td>2011</td>
<td>0.379</td>
<td>0.491</td>
<td>0.289</td>
</tr>
<tr>
<td>2012</td>
<td>0.357</td>
<td>0.444</td>
<td>0.289</td>
</tr>
</tbody>
</table>

Mean 0.401 0.503 0.317
Median 0.392 0.505 0.301
<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Firms</th>
<th>Number of Multinationals</th>
<th>Correlation between ORBIS growth and GDP growth</th>
<th>Ratio of ORBIS revenue to total revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>15,300</td>
<td>2,202</td>
<td>0.83</td>
<td>0.63</td>
</tr>
<tr>
<td>Australia</td>
<td>766</td>
<td>208</td>
<td>0.60</td>
<td>0.70</td>
</tr>
<tr>
<td>Belgium</td>
<td>18,362</td>
<td>3,606</td>
<td>0.91</td>
<td>0.70</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>120,520</td>
<td>1,444</td>
<td>0.92</td>
<td>0.71</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>85,422</td>
<td>7,007</td>
<td>0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Germany</td>
<td>224,395</td>
<td>10,010</td>
<td>0.89</td>
<td>0.69</td>
</tr>
<tr>
<td>Estonia</td>
<td>47,132</td>
<td>1,537</td>
<td>0.96</td>
<td>0.71</td>
</tr>
<tr>
<td>Spain</td>
<td>519,129</td>
<td>9,034</td>
<td>0.82</td>
<td>1.07</td>
</tr>
<tr>
<td>Finland</td>
<td>106,222</td>
<td>2,301</td>
<td>0.93</td>
<td>0.93</td>
</tr>
<tr>
<td>France</td>
<td>751,859</td>
<td>14,581</td>
<td>0.96</td>
<td>0.81</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>194,711</td>
<td>22,459</td>
<td>0.59</td>
<td>0.69</td>
</tr>
<tr>
<td>Greece</td>
<td>24,639</td>
<td>1,262</td>
<td>0.74</td>
<td>0.54</td>
</tr>
<tr>
<td>Croatia</td>
<td>60,527</td>
<td>2,293</td>
<td>0.96</td>
<td>0.75</td>
</tr>
<tr>
<td>Hungary</td>
<td>174,795</td>
<td>822</td>
<td>0.99</td>
<td>0.76</td>
</tr>
<tr>
<td>Ireland</td>
<td>14,131</td>
<td>2,579</td>
<td>0.56</td>
<td>1.03</td>
</tr>
<tr>
<td>Italy</td>
<td>556,874</td>
<td>12,640</td>
<td>0.96</td>
<td>0.79</td>
</tr>
<tr>
<td>Japan</td>
<td>217,024</td>
<td>282</td>
<td>0.81</td>
<td>0.84</td>
</tr>
<tr>
<td>Korea, Rep.</td>
<td>95,112</td>
<td>598</td>
<td>0.68</td>
<td>0.78</td>
</tr>
<tr>
<td>Lithuania</td>
<td>7,473</td>
<td>631</td>
<td>0.96</td>
<td>0.53</td>
</tr>
<tr>
<td>Latvia</td>
<td>43,887</td>
<td>1,093</td>
<td>0.91</td>
<td>0.59</td>
</tr>
<tr>
<td>Mexico</td>
<td>6,102</td>
<td>485</td>
<td>0.49</td>
<td>0.93</td>
</tr>
<tr>
<td>Netherlands</td>
<td>10,061</td>
<td>2,163</td>
<td>0.81</td>
<td>0.40</td>
</tr>
<tr>
<td>Norway</td>
<td>148,599</td>
<td>3,708</td>
<td>0.80</td>
<td>0.81</td>
</tr>
<tr>
<td>Poland</td>
<td>56,414</td>
<td>6,780</td>
<td>0.82</td>
<td>0.68</td>
</tr>
<tr>
<td>Portugal</td>
<td>212,761</td>
<td>2,047</td>
<td>0.89</td>
<td>0.93</td>
</tr>
<tr>
<td>Romania</td>
<td>319,347</td>
<td>4,700</td>
<td>0.86</td>
<td>0.55</td>
</tr>
<tr>
<td>Serbia</td>
<td>48,083</td>
<td>2,428</td>
<td>0.62</td>
<td>0.74</td>
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<tr>
<td>Sweden</td>
<td>222,882</td>
<td>3,942</td>
<td>0.79</td>
<td>0.93</td>
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<tr>
<td>Singapore</td>
<td>1,249</td>
<td>351</td>
<td>0.64</td>
<td>0.64</td>
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<tr>
<td>Slovenia</td>
<td>29,868</td>
<td>559</td>
<td>0.90</td>
<td>0.77</td>
</tr>
<tr>
<td>Slovak Rep.</td>
<td>30,377</td>
<td>3,004</td>
<td>0.75</td>
<td>0.88</td>
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<tr>
<td>Turkey</td>
<td>7,975</td>
<td>286</td>
<td>0.77</td>
<td>0.77</td>
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<tr>
<td>Ukraine</td>
<td>218,489</td>
<td>2,489</td>
<td>0.79</td>
<td>0.80</td>
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<tr>
<td>United States</td>
<td>97,378</td>
<td>605</td>
<td>0.84</td>
<td>0.09</td>
</tr>
<tr>
<td>Mean</td>
<td>179,273</td>
<td>5,270</td>
<td>0.83</td>
<td>0.78</td>
</tr>
<tr>
<td>Median</td>
<td>100,667</td>
<td>2,297</td>
<td>0.87</td>
<td>0.76</td>
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</table>
The importance of multinationals

- Account for a large share of revenue (1/4 at the median)
- Larger than domestic firms
Largest firms

share of 5 largest foreign firms

share of largest foreign firm

back
Growth correlations

WDI correlation, 1994−2007

MPshares

-20 -15 -10 -5 0
Counterfactual variances: correlation in parent-affiliate growth

![Graph showing the relationship between median stv and phi]