# IS PRODUCTIVITY GROWTH SHARED IN A GLOBALIZED ECONOMY?

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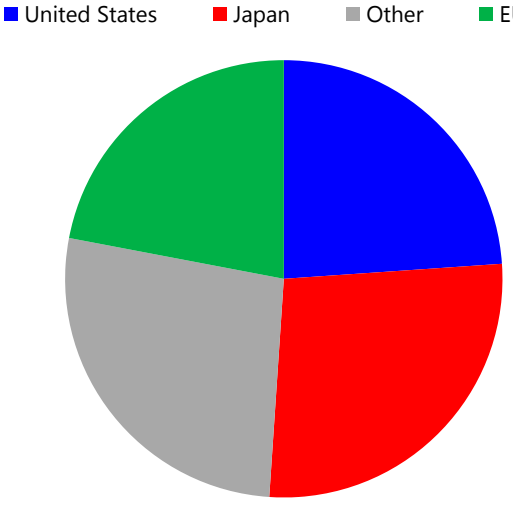
## Motivation

**International patent families by publication year**
*(average 1995-2014)*




Sources: European Patent Office, PATSTAT database; and IMF staff calculations.
Note: EU G–3 = France, Germany, and the United Kingdom.

- **Technological development concentrated** in few large industrial economies
- Technology diffusion **crucial for how global growth generated and shared**
- Literature suggests globalization has **changed diffusion process**, highlighting importance of trade and FDI

# Research Questions

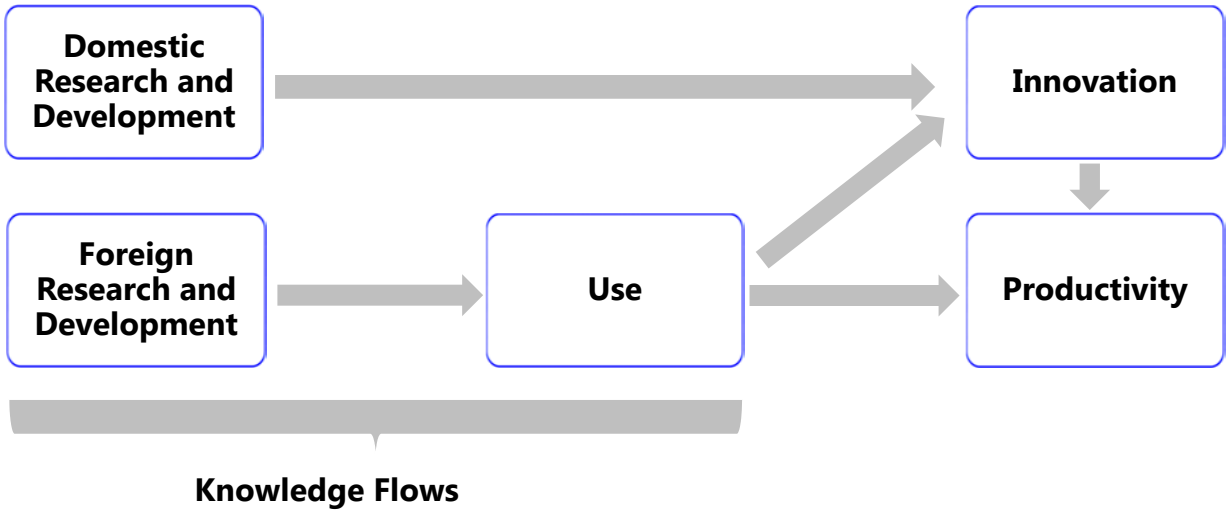
1. Do foreign knowledge flows increase domestic innovation and productivity?
2. What impact does globalization have on innovation and technology diffusion?
3. What policies help increase inward technology diffusion?



# Outline

1. **Conceptual framework** and measurements of innovation and diffusion
2. **Trends** in R&D, patenting, and productivity at the technology frontier and in other advanced and emerging market economies
3. Strength of **international technology diffusion** and its effects on productivity
4. Influence of two particular **aspects of globalization**
   - Global Value Chains (GVCs)
   - Increase of international competition

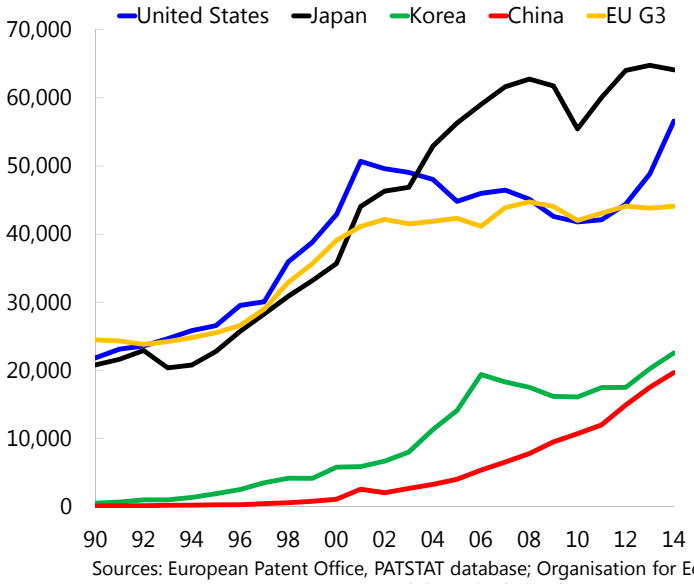
# Conceptual Framework



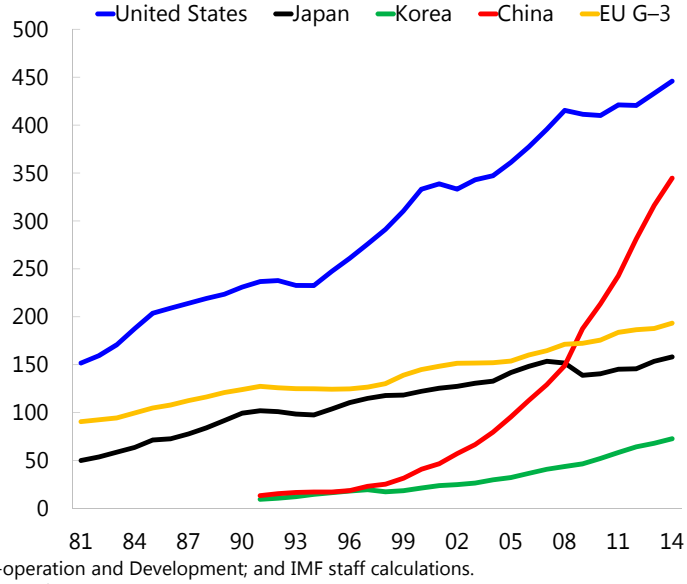



# Patenting slows down more than R&D

**Patenting**
*(international patent families, by publication year)*



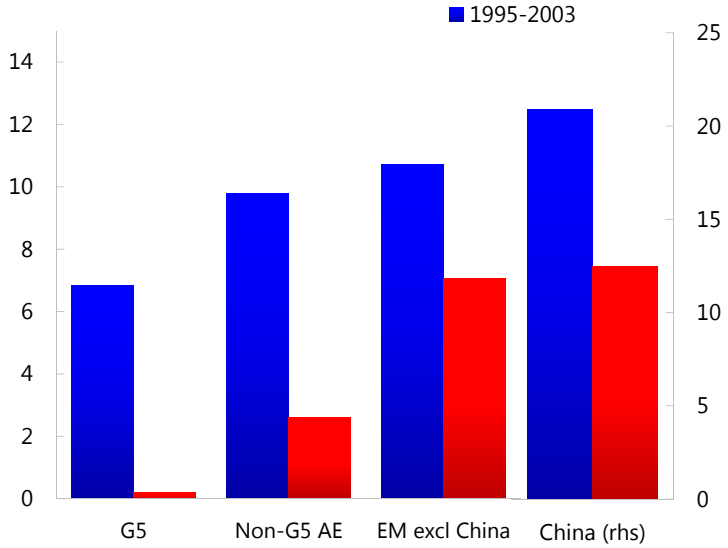

**Business enterprise expenditure on research and development**
*(billions; constant USD PPPs)*



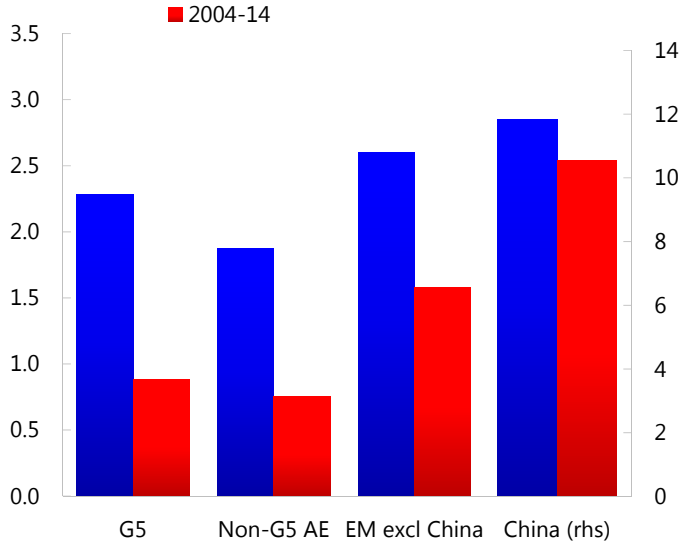

Sources: European Patent Office, PATSTAT database; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: EU G–3 = France, Germany, and the United Kingdom; PPP = purchasing power parity.

# AEs vs EMs: slowdown at the frontier

**Patenting growth**
*(average annual percent growth)*



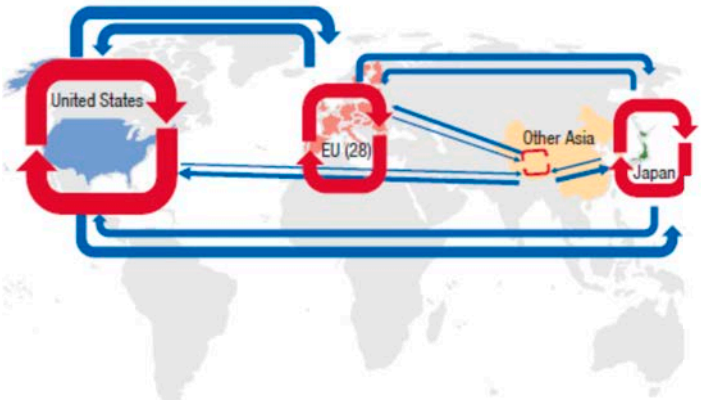

**Labor productivity growth**
*(average annual percent growth)*

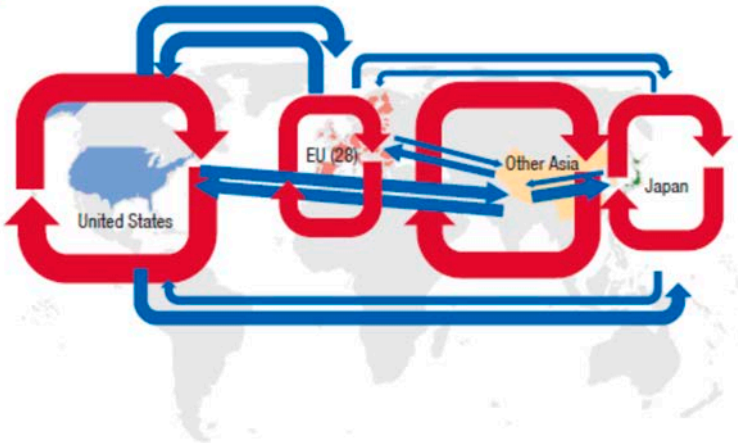



Sources: PATSTAT; Klems; UNIDO; and IMF staff estimates.
Note: simple average of country sector data.



# Knowledge: a more and more integrated world




Sources: European Patent Office, PATSTAT database; and IMF staff calculations.Note: Figure shows the evolution in citation flows between (blue) and within (red) key countries and regions. For a given year, the thickness of tl arrows is proportional to the respective numbers of citations. For visibility, the increase in citations over time could not be reflected proportionally (approximate scaling factor 2014 versus 1995 is 1.5 in the figure; actual is 2.5). (28) = AUT, BEL, BGR, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HRV, HUN, IRL, ITA, LTU, LUX, LVA, MLT, NLD, POL, PRT, ROU, SVK, SVN, SWE; Other Asia = China and Korea. Data labels in the figure use International Organizatio for Standardization (ISO) country codes.

# Gravity Model for Knowledge Flows

Gravity Model at country-industry level (following Peri, 2005) to explain **number of citations** on geographic, linguistic and technological variables

$$\Phi_{i,n;i,m} = \exp[a + \rho_{i,n} + \vartheta_{i,m} + b_1(diff.sector) + b_2(diff.country) + b_3(diff.border) + b_4(diff.lang) + b_5(dist.int) + b_6(tech.spec) + b_7(tech.dev) + \varepsilon_{i,n;i,m}]$$

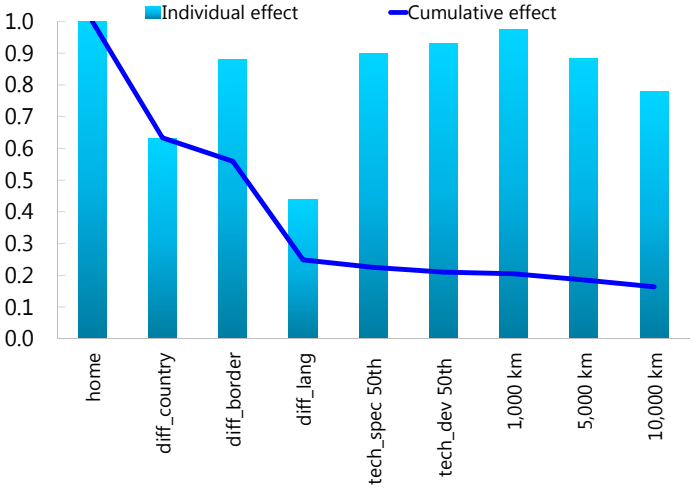
$\widehat{\Phi}$ is the predicted share of knowledge that diffuses from the cited to the citing relative to what diffuses within the cited country sector, one for same country-sector pairs



# Barriers and access to knowledge

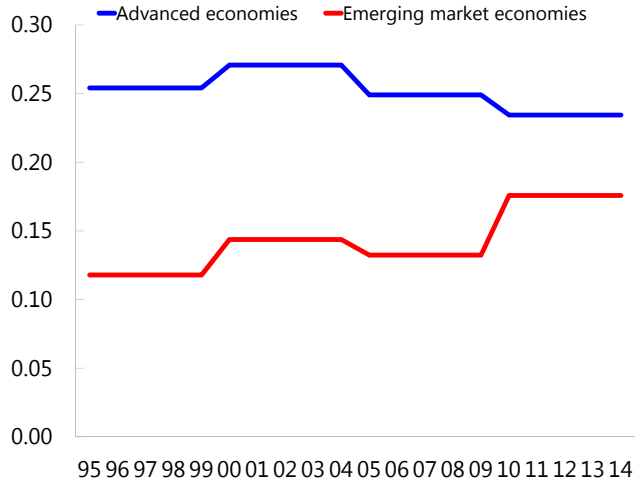
**Reduction in knowledge flow with additional barriers**

*(number of citations relative to G–5 countries to within country-sector citations)*




**Accessibility of G–5 knowledge**

*(predicted average share of knowledge from same sector-regression; estimation by 5-year periods)*




Source: IMF staff calculations. Note: G–5 = France, Germany, Japan, the United Kingdom, and the United States; Charts are derived from coefficients of same-sector regression on citations to G–5 countries. Tech_spec 50th denotes the 50th percentile of the variable tech_spec; and tech_dev 50th denotes the 50th percentile of the variable tech_dev. km = kilometers.

# Impact of R&D on Innovation & Productivity

Investigate how **innovation** (patent *flow*) or **productivity** (*P*) in the recipient country sector depends on:

- its own (domestic) R&D *stock* ( $R_{i,c}$)
- the weighted total R&D *stock* of the five technology leaders ( $R_{i,l}$ ).

Following Peri (2005); Coe, Helpman, and Hoffmaister (2009); Acharya and Keller (2009)

$$lnP_{i,c,t} = D_{c,t} + \gamma lnR_{i,c,t} + \mu \ln \sum_{l \neq c} \phi_{i,c,l,t} R_{i,l,t} + \varepsilon_{i,c,t}$$

$\phi$ = relative weight on each leader's R&D stock, from previous analysis

$\mu$ = average efficiency of use of foreign knowledge



# Impact of Foreign Knowledge on Domestic Innovation and Productivity

| Dependent Variable | Patent Flow | | Labor Productivity | | Total Factor Productivity | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Sample period (1995–2014) | Baseline | Changing Diffusion | Baseline | Changing Diffusion | Baseline | Changing Diffusion |
| Foreign R&D Stock, weighted[1] | 0.350*** | 0.199*** | 0.057*** | 0.040* | 0.053** | 0.018 |
| | [0.055] | [0.057] | [0.020] | [0.022] | [0.021] | [0.037] |
| Foreign R&D Stock*2000–04 | | 0.137*** | | 0.039*** | | 0.026* |
| | | [0.031] | | [0.012] | | [0.014] |
| Foreign R&D Stock*2005–09 | | 0.191*** | | 0.043** | | 0.052** |
| | | [0.039] | | [0.018] | | [0.024] |
| Foreign R&D Stock*2010–14 | | 0.259*** | | -0.009 | | 0.072** |
| | | [0.048] | | [0.026] | | [0.030] |
| Own R&D Stock | 0.448*** | 0.441*** | 0.118*** | 0.118*** | 0.060** | 0.058* |
| | [0.061] | [0.060] | [0.022] | [0.022] | [0.023] | [0.030] |
| Observations | 3,487 | 3,487 | 3,721 | 3,721 | 1,192 | 959 |
| $R^2$ | 0.779 | 0.784 | 0.758 | 0.759 | 0.958 | 0.955 |
| Country-Year Fixed Effects | YES | YES | YES | YES | YES | YES |

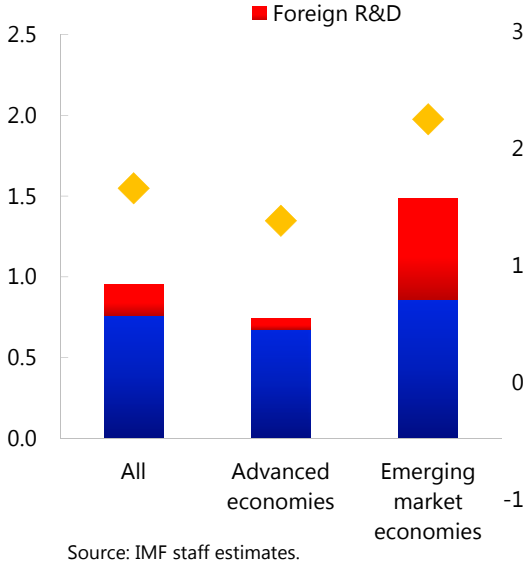
Source: IMF staff calculations.

Note: R&D = research and development. Robust standard errors (clustered at country-sector level) in brackets. *** p<0.01, ** p<0.05, * p<0.1

[1]Regression equations for labor productivity and total factor productivity use the lag value of the weighted Foreign R&D stock variable.

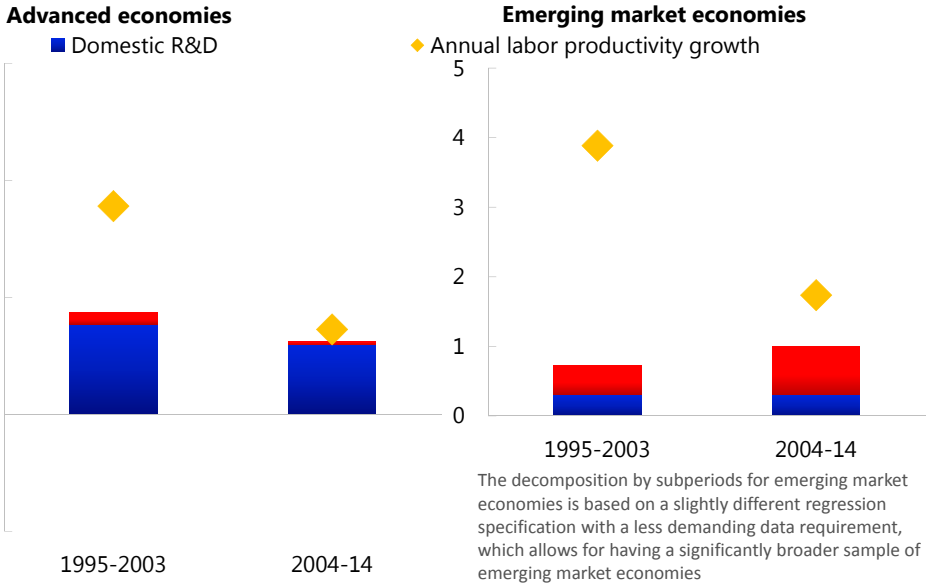
# Contribution of Foreign Knowledge to Labor Productivity Growth

**Contribution of foreign knowledge to labor productivity growth, 1995-2014**
*(average annual percent growth)*




Source: IMF staff estimates.

**Contribution of foreign knowledge to labor productivity growth, by subperiod**
*(average annual percent growth)*




The decomposition by subperiods for emerging market economies is based on a slightly different regression specification with a less demanding data requirement, which allows for having a significantly broader sample of emerging market economies



# Innovation and Productivity: Additional Results

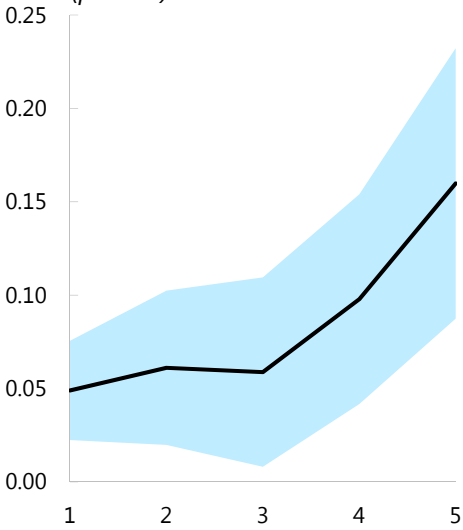
Long-run relation between foreign R&D stock and innovation is robust to various sensitivity analyses

Similar **for AEs and EMs**, though
- bigger coefficient on own R&D for AEs,
- coefficient for foreign R&D has increased more for EMs

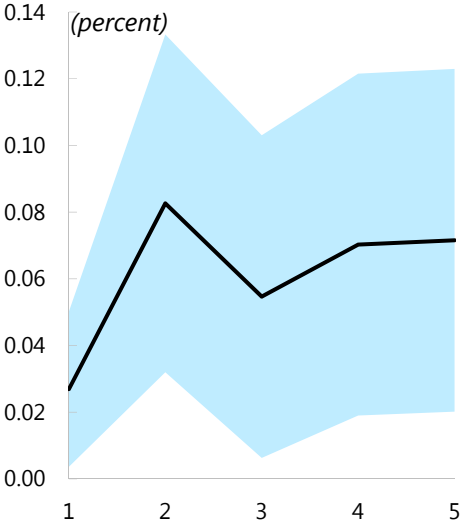
Other robustness:
- **Broader EM sample:** by replacing sectoral R&D by aggregate R&D x US R&D intensity
- **Dynamic OLS:** to address possible cointegration between R&D and labor productivity
- **Alternative weights**: Top 3 patent measure and actual trade weights
- **Fixed Effects:** country-time instead of sector-time

# The Dynamics of Technology Diffusion

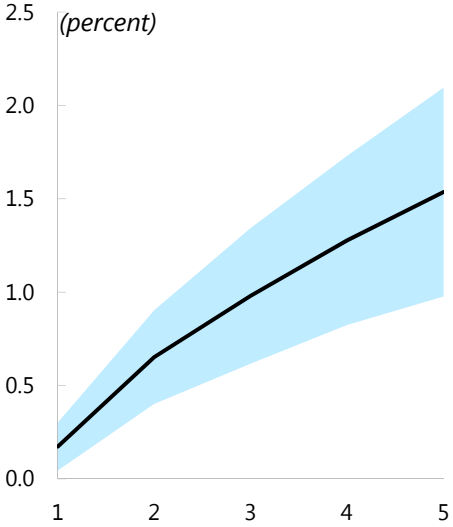
**Response of recipient TFP to a TFP shock in leaders**
*(percent)*




**Response of recipient labor productivity to a technology shock in leaders**
*(percent)*




**Response of recipient patenting to a patenting shock**
*(percent)*

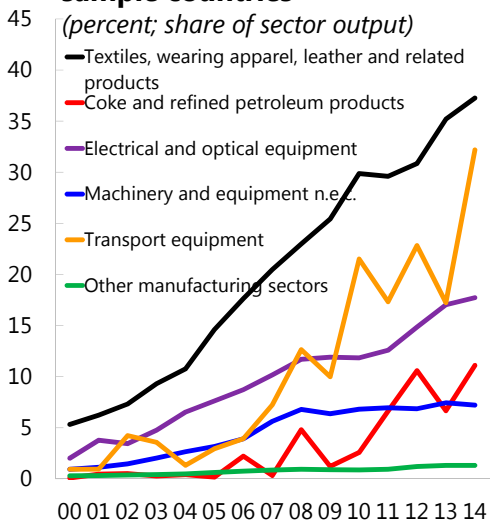



Source: IMF staff estimates. Note: TFP = total factor productivity. Blue shade denotes 90 percent confidence band. Impulse responses to a 1 percent TFP/labor productivity/patent shock estimated using local projections. X-axes denote years; t = 1 is the year of the shock.

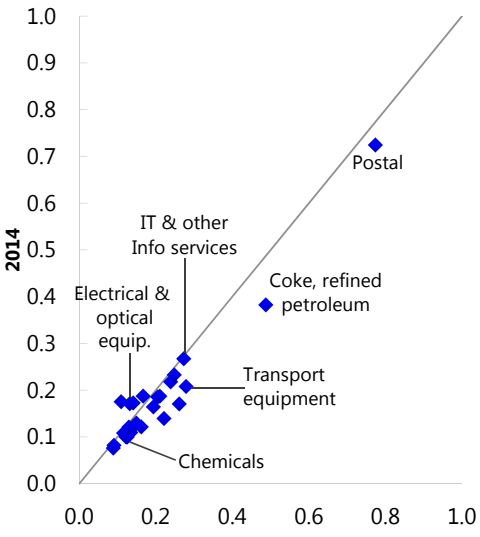


# Impact of globalization: Competition

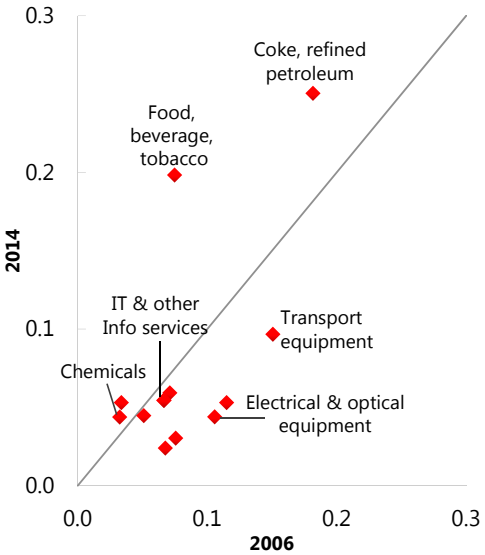
**Imports of final goods from China, by sector, average for sample countries**
*(percent; share of sector output)*




**Top 4 share in global sales**



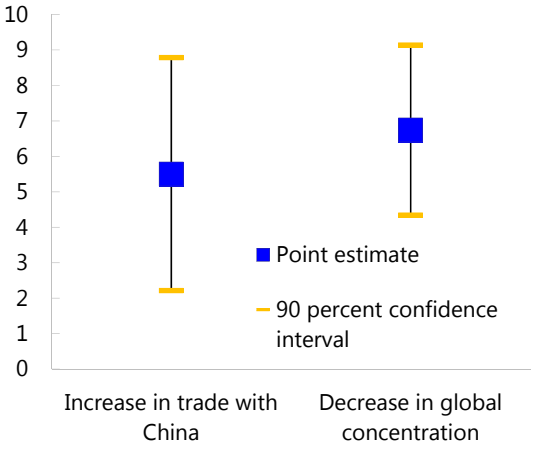

**Top 4 share in global patent families**




Sources: Freund and Sidhu 2017; PATSTAT; WIOT; and IMF staff calculations.

# The Effect of Competition on Innovation and Technology Diffusion

**Direct impact on innovation**
*(percent)*




Source: IMF staff calculations.
Note: Estimated change in the recipient's patenting activity in response to the average change in the structural factors over the sample period. Lower and upper bounds denote the 90 percent confidence interval.

**Impact of Competition on Innovation**

| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Foreign R&D Stock | 0.337*** | 0.413*** | 0.335*** | 0.405*** |
| | [0.054] | [0.046] | [0.045] | [0.075] |
| Own R&D Stock | 0.494*** | 0.435*** | 0.447*** | 0.478*** |
| | [0.063] | [0.055] | [0.061] | [0.059] |
| China Trade | 2.465*** | | | 2.086*** |
| | [0.777] | | | [0.758] |
| Foreign R&D Stock*China Trade | 1.474*** | | | 1.236*** |
| | [0.442] | | | [0.394] |
| Global Concentration | | -4.021*** | | -4.059*** |
| | | [0.923] | | [0.879] |
| Foreign R&D Stock*Global Concentration | | -2.121*** | | -2.27*** |
| | | [0.559] | | [0.565] |
| PMR*Firm Turnover | | | -0.021*** | 0.02 |
| | | | [0.007] | [0.019] |
| Foreign R&D Stock*(PMR*Firm Turnover) | | | -0.01*** | 0.004 |
| | | | [0.003] | [0.008] |
| Observations | 2,281 | 1,559 | 2,533 | 1,175 |
| $R^2$ | 0.801 | 0.819 | 0.789 | 0.832 |
| Country-Year Fixed Effect | YES | YES | YES | YES |

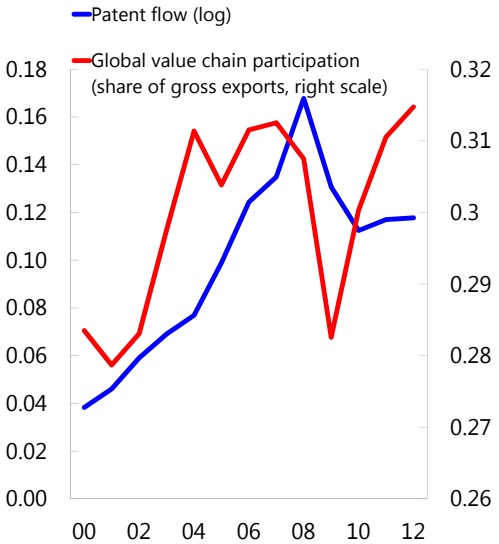
Source: IMF staff calculations.

Note: PMR = product market regulation; R&D = research and development.
Robust standard errors (clustered at country-sector level) in brackets. *** p<0.01, ** p<0.05, * p<0.1.



# Impact of Globalizaiton: GVC Participation

**Trends in average firm patenting and GVC participation**



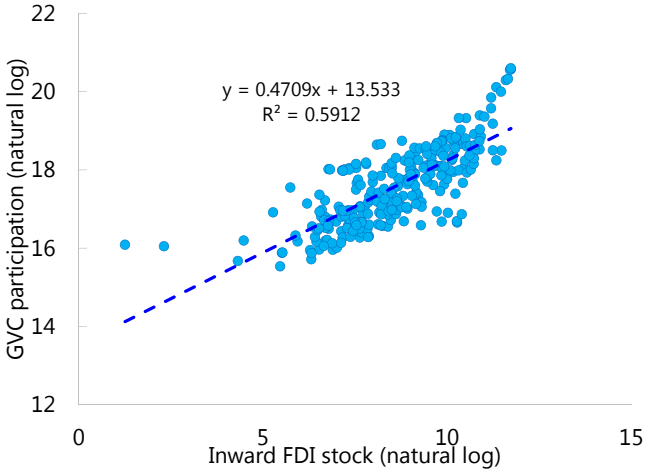

Global Value Chains can have **opposing effects on local innovation:**

- Opportunity for **knowledge transfer** along the value chains through new practices, specialization and higher quality inputs
- Possible **relocation of existing innovation** within multinational firm to where most efficient

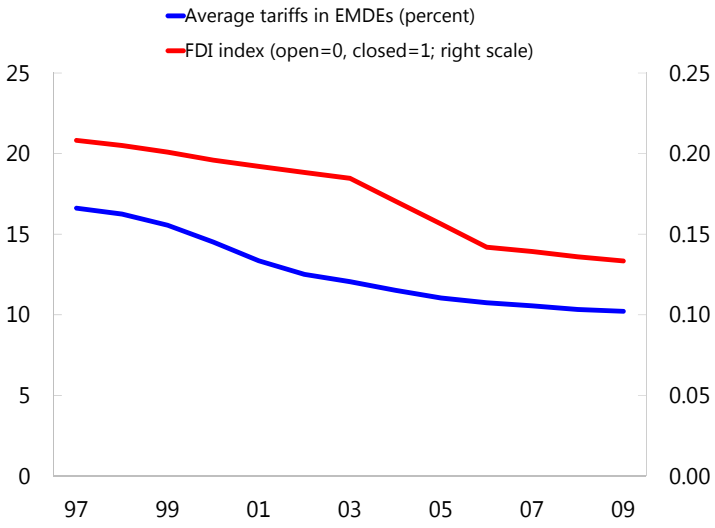
Sources: EORA Multi-Region Input-Output database; External Wealth of Nations; European Patent Office, PATSTAT; Foreign Direct Investment statistics; IMF, October 2016 World Economic Outlook; Orbis; United Nations Conference on Trade and Development; and IMF staff calculations.
Note: EMDEs = emerging market and developing economies. FDI = foreign direct investment. GVC = global value chain.

# Instrumental Variable Approach

**GVC participation vs. inward FDI stocks**




**FDI restrictions and tariffs in EMDEs**




Sources: EORA Multi-Region Input-Output database; External Wealth of Nations; European Patent Office, PATSTAT; Foreign Direct Investment statistics; IMF, October 2016 World Economic Outlook; Orbis; United Nations Conference on Trade and Development; and IMF staff calculations.
Note: EMDEs = emerging market and developing economies. FDI = foreign direct investment. GVC = global value chain.



# The Impact of Global Value Chains on Patenting and Employment

| Dependent Variable | Patent Flow (Log, five-year difference) | | Employment (Log, five-year difference) |
|---|---|---|---|
| | (1) | (2) | (3) |
| Sample Period (2002–2012) | OLS (PATSTAT Firms) | IV (PATSTAT Firms)[1] | OLS (Matched ORBIS - PATSTAT Firms) |
| **Initial Patent Stock (2000)** | -0.07*** | -0.09*** | -0.02* |
| | [-5.703] | [-30.002] | [-1.873] |
| ***Within-firm Effects*** | | | |
| **GVC Participation (Five-year change)** | 0.28*** | 0.98*** | 1.82*** |
| | [3.133] | [7.420] | [8.002] |
| ***Between-firm Effects*** | | | |
| **Initial Patent Stock (2000) x** | -1.31*** | -1.67*** | 0.91* |
| **GVC Participation (Five-year change)** | [-4.160] | [-4.963] | [1.943] |
| **Observations** | 4,044,066 | 2,928,882 | 87,929 |
| $R^2$ | 0.026 | 0.030 | 0.182 |
| **Country x year Fixed Effects** | YES | YES | YES |
| **Sector Fixed Effects** | YES | YES | YES |

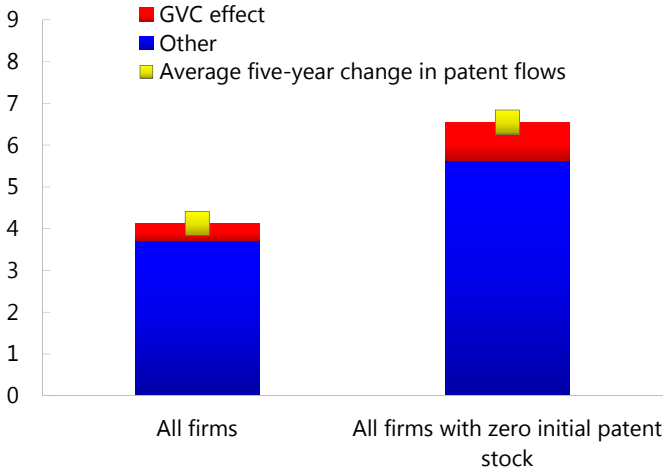
Source: IMF staff estimates.
[1] Instruments include foreign personnel restrictions (percent-year difference and level), screening and approval procedures (level) and tariffs (five-year difference). (See Annex 4.5 for details).

Note: GVC = global value chain. IV = instrumental variable estimation. OLS = ordinary least squares. Robust t-statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1.

# The Quantitative Effect on Patenting and the Influence of Policy Variables

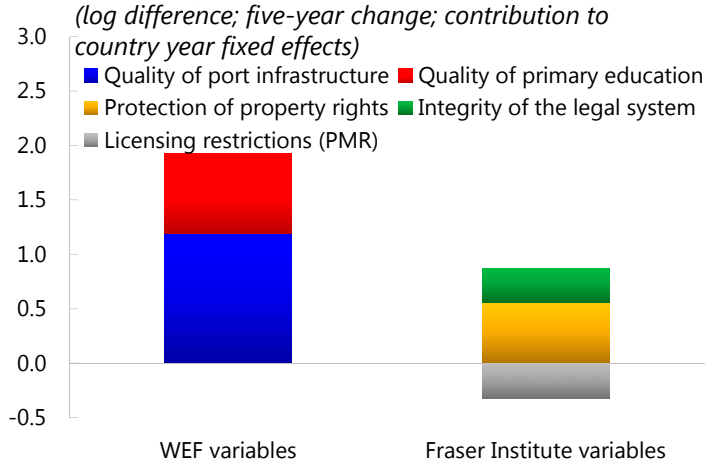
**Change in average firm patenting and GVC participation**

*(log difference; simulation based on full sample)*




**Predicted relation between selected policy variables and change in average firm patenting**

*(log difference; five-year change; contribution to country year fixed effects)*




Sources: EORA Multi-Region Input-Output database; European Patent Office, PATSTAT database; Fraser Institute, Economic Freedom of the World; World Economic Forum Global Competitiveness Report; and IMF staff calculations. Note: Panel 1 shows result of a simulation based on the full sample. Panel 2 shows the five-year change of contribution to country year fixed effects. GVC = global value chain. PMR = product market regulation. WEF = World Economic Forum Global Competitiveness Report.



# Summary

1. Diffusion of knowledge and technology **has intensified**

   and boosted innovativeness and productivity

2. Positive impact for **EMs** particularly large. Driving cross-country income convergence.

3. Two roles of **globalization**: competition and GCV participation

4. **Not a one-way flow**: Future scope for positive spillovers from new global innovators to traditional innovators.

# Policy implications

1. Support for **globalization**/interconnectedness (FDI regulation, trade barriers, infrastructure)

2. Investment in **absorptive capacity**, given tacit component of knowledge (R&D, investment in human capital)

3. Appropriate **protection and respect of IPR**—to provide right incentives for innovation and diffusion without discouraging further innovation

4. Ensuring **gains are broadly shared**, including by supporting adjustment (education/reskilling/structural reforms, competition policy, possibly redistribution policies)