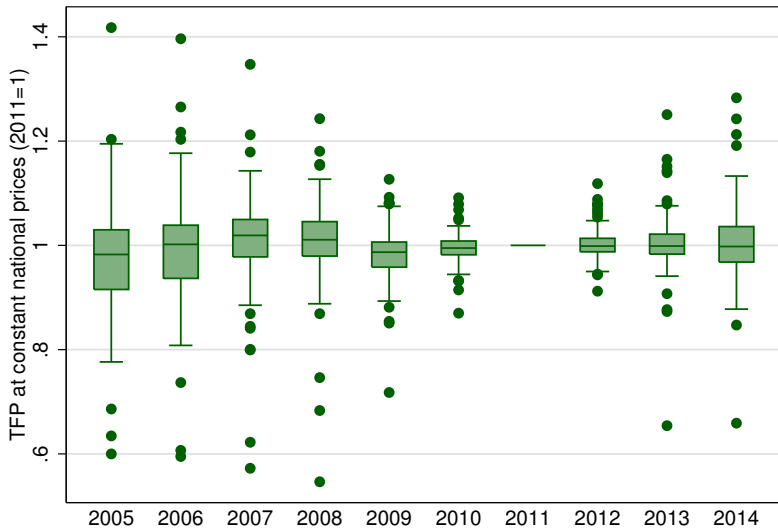


Productivity dispersion and slowdown: a knowledge diffusion story?

Dany Bahar (Brookings and Harvard CID)
Sebastian Strauss (Brookings)

KDI-Brookings Workshop
January 2017

Figure: Total Factor Productivity by year (world distribution)



Source: Penn World Tables 9.0

Motivation and Research Question

- Overall **slowdown in aggregate productivity** (e.g. Syverson, 2016; Bailey and Montalbano, 2016; Andrews et al. 2016):
 - Mismeasurement (see discussion in Syverson, 2016);
 - Slowdown in supply of innovation (e.g. Gordon, 2015; Cowen, 2011);
 - Decline in firm adoption and diffusion rates for new technologies (e.g. Comin and Hobijn, 2010; Anzoategui et al. 2015)
- Within industry productivity dispersion is high (e.g. Hsieh and Klenow, 2003; Syverson, 2004)
- This paper studies (i) dynamics of productivity dispersion; (ii) link between dispersion and productivity growth; (iii) determinants of productivity dispersion

Main findings

- Using standardized firm-level for 17M firms in ~40 countries I find robust "convergence-divergence" TFP growth dynamics:
 - Convergence up to firms in 99th percentile of TFP: 99th percentile's estimated 3-yr CAGR of 99th is up to ~5pp higher than for 75th percentile
 - U-shaped convergence is stronger for developing countries, as well as for manufacturing and for IT and financial services sectors
- Initial levels of dispersion negatively correlates w/ growth rates
 - a 1 s.d. increase in dispersion is associated to ~1pp points decrease in CAGR

Main findings (cont)

- Find evidence suggesting TFP dispersion decreases are better explained for:
 - dynamic industries (prone to competition) under regulation that favors domestic competition
 - less so for foreign competition...
 - knowledge intensive industries in environments more beneficial to innovation and entrepreneurship
 - high labor mobility industries under regulations that promote talent attraction and retention
 - less so for flexibility in labor markets
 - ICT intensive industries in countries with higher educational attainment (weak)

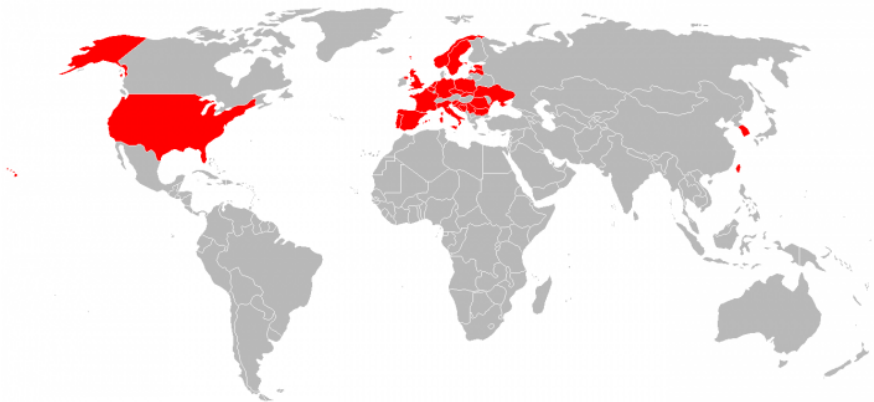
Roadmap

- Data and Productivity Measurement
- Results
- Concluding Remarks

- Main source: Bureau Van Dijk's Orbis dataset
 - other papers using it are Bloom et al. 2012, Fons-Rosen et al. 2013
- We complement US firms using COMPUSTAT
- Final database includes complete information to compute TFP for ~17M firms in 38 countries and ~500 6-digit NAICS codes, between years 2006 to 2014 [▶ Country List](#)

Countries in the Sample

Figure: Countries in the Sample



Estimating TFP

- We estimate elasticities for labor, capital and materials using 4 methodologies:
 - Ordinary Least Squares, per country and 3-digit industries
 - Levinsohn and Petrin (2003) following Wooldridge (2009), per country and 3-digit industries, using 1, 2 and 3 lags as instrumental variables
 - Computing average cost shares per country, year and 3 digit industry
 - Computing plant-specific cost shares
- All measures are highly correlated. We stick in this presentation to industry-level cost shares, since it provides the largest sample.

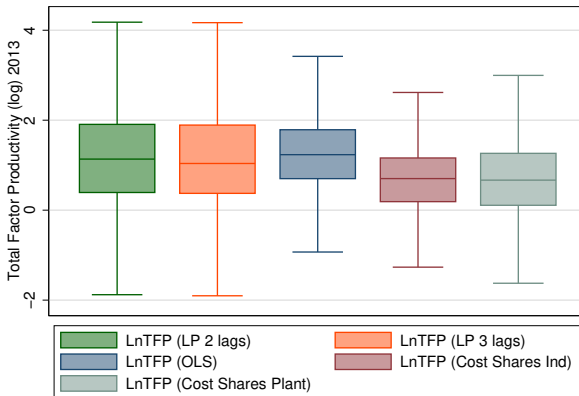
Different TFP Measures

Table: TFP Correlation Table

Variables	LnTFP (Cost Shares Ind)	LnTFP (Cost Shares Plant)	LnTFP (LP 2 lags)	LnTFP (LP 3 lags)	LnTFP (OLS)
LnTFP (Cost Shares Ind)	1.000				
LnTFP (Cost Shares Plant)	0.891	1.000			
LnTFP (LP 2 lags)	0.571	0.504	1.000		
LnTFP (LP 3 lags)	0.558	0.491	0.958	1.000	
LnTFP (OLS)	0.608	0.529	0.745	0.739	1.000

Different TFP Measures

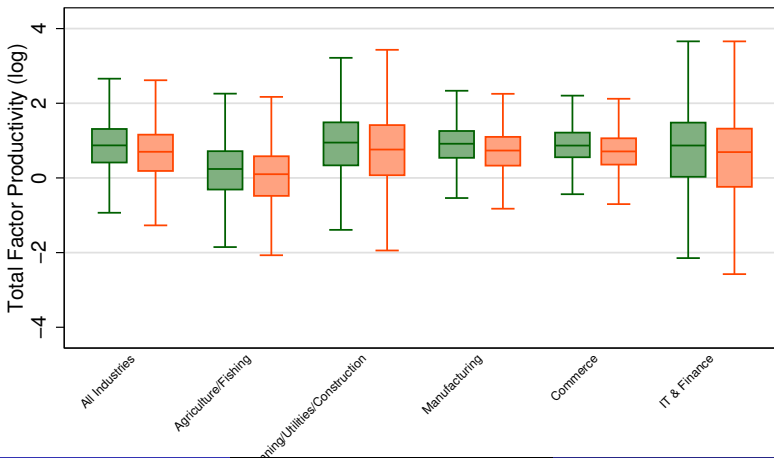
Figure: TFP comparison using different methods



For visualization purposes, the graph excludes severe outliers in the distribution.

Descriptive Stats

Figure: TFP Distribution by Industry, 2008-2013



Descriptive Stats

Table: TFP Dispersion Statistics (all years)

Measure	Mean	25th	Median	75th	Std. Dev.
IQ ratio	2.42	1.56	1.93	2.61	2.56
99th-Median ratio	5.95	2.91	4.14	6.25	39.88
90th-10th ratio	8.97	2.58	4.09	7.73	67.31
95th-5th ratio	29.41	3.92	7.37	17.44	302.43

Descriptive Stats

Table: TFP Dispersion Statistics, Manufacturing only (all years)

Measure	Mean	25th	Median	75th	Std. Dev.
IQ ratio	1.78	1.50	1.66	1.96	0.40
99th-Median ratio	3.68	2.42	3.11	4.03	3.03
90th-10th ratio	3.61	2.32	2.88	4.11	2.33
95th-5th ratio	6.97	3.30	4.49	7.42	8.88

Transition Matrix

Table: TFP Transition Matrix

		2013				
		1	2	3	4	5
2008	1	0.55	0.26	0.14	0.08	0.06
	2	0.23	0.36	0.26	0.15	0.08
	3	0.10	0.22	0.31	0.26	0.14
	4	0.06	0.10	0.21	0.33	0.26
	5	0.05	0.06	0.09	0.18	0.45

Transition Matrix (Manufacturing Only)

Table: TFP Transition Matrix (Manufacturing Only)

		2013				
		1	2	3	4	5
2008	1	0.56	0.26	0.13	0.07	0.06
	2	0.24	0.36	0.26	0.15	0.08
	3	0.10	0.23	0.31	0.26	0.13
	4	0.06	0.11	0.22	0.33	0.25
	5	0.04	0.04	0.08	0.19	0.48

Growth Regressions

- Is the slow down in productivity growth across the board?
- Can we identify any pattern that relates to the increasing dispersion over the years?
- I run a simple growth regression:

$$TFP_CAGR_{f,c,i,t \rightarrow T} = \beta \times TFP_{f,t} + \eta_{c,t} + \varphi_{i,t} + \varepsilon_{f,c,i,t}$$

- where $T - t = \{3, 5\}$. We allow for a quadratic term to explore non-linearities.

Results: Growth Regression

Table: Growth Regression

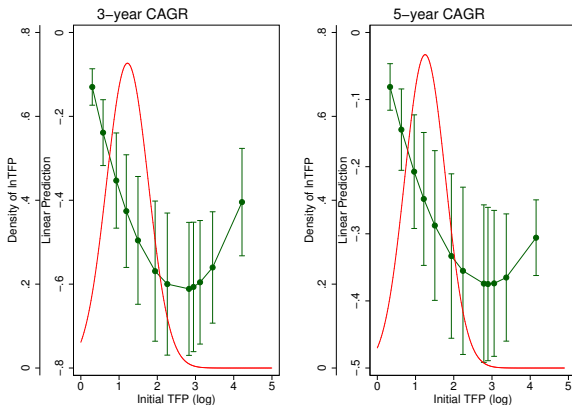
Dependent Variable: TFP Growth Rate (CAGR)				
	3 years		5 years	
	(1)	(2)	(3)	(4)
lnTFP	-0.2049 (0.040)***	-0.4638 (0.107)***	-0.1344 (0.032)***	-0.2651 (0.081)***
lnTFP_sq		0.0900 (0.026)***		0.0441 (0.018)**
N	2185821	2185821	937384	937384
r2	0.07	0.09	0.16	0.18

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results: Growth Regression

Figure: Growth Regression, Graphical Representation



Results: Growth Regression, by industry

Table: Growth Regression, by Industry

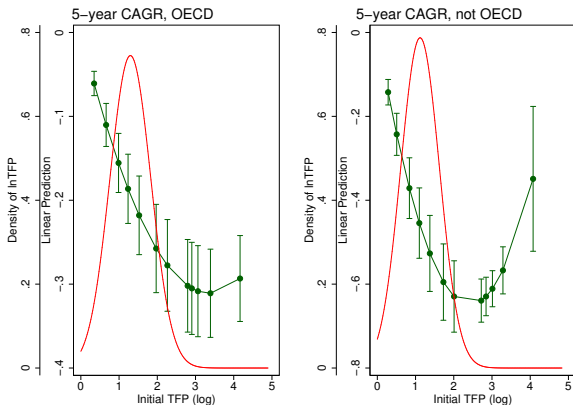
Dependent Variable: TFP 5-year Growth Rate (CAGR)					
	Agriculture	Mining, Utilities, Constr	Mnfr	Commerce	IT & Finance
lnTFP	-0.3496 (0.099)***	-0.3286 (0.045)***	-0.2647 (0.067)***	-0.3185 (0.105)***	-0.2201 (0.064)***
lnTFP_sq	0.0772 (0.027)**	0.0734 (0.014)***	0.0523 (0.014)***	0.0512 (0.023)**	0.0348 (0.015)**
N	30594	129983	183495	366670	226642
r2	0.21	0.14	0.18	0.27	0.13

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results: Growth Regression, OECD vs. non-OECD

Figure: Growth Regression, Graphical Representation

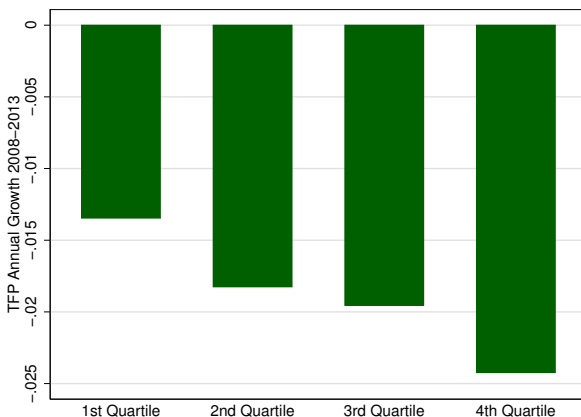


TFP Dispersion and Growth

- The convergence-divergence dynamics is suggestive that there is no lack of innovation, but rather lack of diffusion/adoption of technologies among firms in lower part of TFP distribution
- Is the increased TFP dispersion countering aggregate TFP growth?

TFP Dispersion and Growth

Figure: TFP Real Mean Deviation & agg. TFP 5-year CAGR



TFP Dispersion and Growth

Table: TFP Dispersion & agg. TFP 5-year CAGR

Dependent Variable: TFP 5-year Growth Rate (CAGR)						
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev
Dispersion	-0.0646 (0.031)**	-0.0084 (0.002)***	0.0100 (0.013)	-0.0501 (0.027)*	-0.0264 (0.007)***	-0.0046 (0.016)
lnTFP	-0.0643 (0.010)***	-0.0635 (0.011)***	-0.0680 (0.011)***	-0.0646 (0.010)***	-0.0630 (0.011)***	-0.0668 (0.011)***
N	3999	3999	3999	3999	3999	3999
r ²	0.28	0.29	0.28	0.28	0.29	0.28

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Understanding dispersion

- We test for a number of different hypothesis of determinants of dispersion, estimate:

$$\Delta dispersion_{c,i,t \rightarrow t+5} = \alpha IndustryVar_i \times CountryVar_c + \eta_{c,t} + \varphi_{i,t} + \varepsilon_{c,i,t}$$

- We use variables from several sources to create a number of industry and country level variables
 - Sources include WEF, World Bank, OECD, EUKLEMS and individual researchers
- We test a large number of hypotheses. Here we present the most robust and consistent results.

Education Quality and ICT Intensity

Table: Dispersion and Education

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
ICT intensity × (ln) Education quality	-0.9151 (0.450)*	-5.0555 (4.373)	-0.8951 (0.671)	-0.9746 (0.479)*	-3.4123 (1.864)*	-2.0700 (1.114)*	-2.5257 (1.745)	-1.7027 (1.640)
N	2543	2543	2543	2543	2543	2543	2543	2543
r2	0.17	0.13	0.24	0.18	0.15	0.19	0.14	0.21

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Knowledge Intensity and R&D

Table: Dispersion and Innovation

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Knowledge Intensity × (ln) RD tax incentives	-0.0041 (0.001)***	-0.0242 (0.006)***	-0.0046 (0.002)**	-0.0046 (0.001)***	-0.0101 (0.002)***	-0.0082 (0.001)***	-0.0063 (0.004)	0.0044 (0.009)
N	2388	2388	2388	2388	2388	2388	2388	2388
r ²	0.18	0.14	0.23	0.19	0.16	0.18	0.16	0.21

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Knowledge Intensity and R&D

Table: Dispersion and Innovation

Dependent Variable: Change in TFP Dispersion Measures									
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1	
(ln) Knowledge Intensity × RD tax subsidy rate	-0.0422 (0.020)*	-0.6451 (0.269)**	-0.0377 (0.028)	-0.0463 (0.026)*	-0.2351 (0.072)***	-0.1340 (0.050)**	-0.1492 (0.095)	-0.2061 (0.156)	
N	2668	2668	2668	2668	2668	2668	2668	2668	
r ²	0.18	0.14	0.21	0.19	0.15	0.18	0.16	0.19	

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Market Dynamism and Entrepreneurship Regulation

Table: Dispersion and Entrepreneurship Environment

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Firm turnover × Recovery Rate	-0.0010 (0.000)**	-0.0068 (0.004)*	-0.0008 (0.001)	-0.0012 (0.000)**	-0.0029 (0.001)**	-0.0022 (0.001)*	-0.0035 (0.001)***	0.0011 (0.003)
N	2368	2368	2368	2368	2368	2368	2368	2368
r2	0.17	0.14	0.22	0.20	0.14	0.16	0.15	0.17

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Market Dynamism and Competition

Table: Dispersion and Competition

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Firm turnover × Competition	-0.0524 (0.019)**	-0.4011 (0.187)**	-0.0553 (0.056)	-0.0560 (0.023)**	-0.1641 (0.066)**	-0.1333 (0.050)**	-0.1726 (0.061)***	0.0049 (0.141)
N	2368	2368	2368	2368	2368	2368	2368	2368
r2	0.17	0.14	0.22	0.20	0.14	0.16	0.15	0.17

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Import penetration and Competition

Table: Dispersion and Competition

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Import competition × Competition	0.0054 (0.011)	0.1219 (0.075)	0.0012 (0.034)	0.0037 (0.013)	0.0413 (0.037)	0.0341 (0.039)	0.0442 (0.049)	0.0602 (0.064)
N	3913	3913	3913	3913	3913	3913	3913	3913
r ²	0.16	0.11	0.20	0.18	0.12	0.15	0.13	0.16

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Market Dynamism, Competition and Tradability

Table: Dispersion and Competition

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Firm turnover × Domestic competition	-0.0497 (0.019)**	-0.3320 (0.179)*	-0.0533 (0.052)	-0.0546 (0.023)**	-0.1423 (0.065)**	-0.1169 (0.050)**	-0.1615 (0.060)**	0.0323 (0.137)
(ln) Import competition × Foreign competition	0.0063 (0.002)***	0.0942 (0.035)**	0.0163 (0.006)**	0.0069 (0.002)***	0.0285 (0.009)**	0.0240 (0.009)**	0.0169 (0.010)	0.0360 (0.016)**
N	2368	2368	2368	2368	2368	2368	2368	2368
r2	0.18	0.15	0.23	0.21	0.14	0.17	0.15	0.17

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Mobility and labor markets

Table: Dispersion and Labor Market Regulation

Dependent Variable: Change in TFP Dispersion Measures									
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1	
(ln) Layoff rate × LME	-0.0068 (0.009)	0.0018 (0.103)	-0.0441 (0.033)	-0.0114 (0.010)	-0.0013 (0.029)	-0.0096 (0.022)	-0.0323 (0.036)	-0.1109 (0.085)	
N	3815	3815	3815	3815	3815	3815	3815	3815	
r ²	0.16	0.12	0.20	0.19	0.13	0.16	0.14	0.15	

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Mobility and labor markets (cont)

Table: Dispersion and Labor Market Regulation

Dependent Variable: Change in TFP Dispersion Measures								
	Rel Mean Dev	Coef Var	Std Dev Log	Gini	Theil	Mean Log Dev	p99p50	p50p1
(ln) Layoff rate × Flexibility	0.0167 (0.007)**	0.1589 (0.077)**	0.0122 (0.023)	0.0161 (0.009)*	0.0593 (0.023)**	0.0425 (0.017)**	0.0465 (0.027)*	0.0175 (0.055)
(ln) Layoff rate × Efficient use of talent	-0.0242 (0.008)***	-0.1621 (0.079)**	-0.0574 (0.029)*	-0.0282 (0.010)***	-0.0624 (0.023)**	-0.0536 (0.020)**	-0.0807 (0.029)**	-0.1307 (0.075)*
N	3815	3815	3815	3815	3815	3815	3815	3815
r2	0.17	0.12	0.20	0.19	0.13	0.16	0.14	0.16

All columns include country-year and product-year fixed effects. Standard errors clustered at the country and product level are presented in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Wrapping up...

- Productivity slowdown came together with an increased dispersion in TFP
- A convergence-divergence dynamics of TFP growth could explain frontier firms outperforming while others lag behind, generating dispersion
- Dispersion in itself is negatively correlated with future growth
- Evidence suggests dispersion is determined by (i) competition (ii) labor markets efficiency (iii) innovation and entrepreneurship policies and (iv) educational attainment



“Knowledge and skill diffusion is the key to overall productivity growth as well as the reduction of inequality both within and between countries” (Piketty, 2014)

The End

Thank you

*For comments, questions and/or suggestions, please contact me at
dbahar@brookings.edu*

Countries List

Table: Country List (Cost Shares)

Country	# Firm-Years	Cum Share
Spain	3,300,839	0.202
Romania	2,675,509	0.365
Italy	2,429,142	0.514
Portugal	1,556,046	0.609
France	1,554,178	0.704
Ukraine	736,863	0.749
Bulgaria	606,184	0.786
Korea, Republic of	486,226	0.816
Czech Republic	471,431	0.845
Croatia	353,456	0.866
Slovakia	336,504	0.887
Serbia	298,333	0.905
Finland	253,380	0.920
Norway	246,289	0.936
Germany	200,983	0.948
Sweden	174,290	0.958
Estonia	141,796	0.967
United Kingdom	134,178	0.975
Slovenia	126,786	0.983
Poland	118,320	0.990
Bosnia and Herzegovina	48,791	0.993
Belgium	47,774	0.996
Hungary	37,379	0.998
USA	12,789	0.999
Hong Kong	4,130	1.000
Latvia	2,811	1.000
Taiwan	2,029	1.000
Ireland	1,576	1.000
Netherlands	746	1.000

The firms in the sample are active in 513 different six-digit NAICS codes