A New Measure of Utilization-Adjusted TFP Growth for European Countries

Diego Comin
Dartmouth and CEPR

Javier Quintana
Bocconi

Tom Schmitz
Bocconi and IGIER

Antonella Trigari
Bocconi, CEPR and IGIER

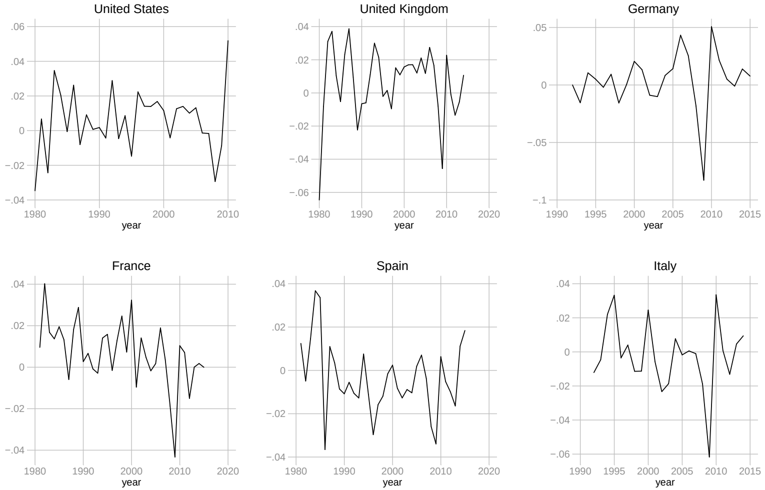
FRAME Final Policy Conference

February 18, 2019

Measuring TFP growth

- Total Factor Productivity (TFP) growth plays a crucial role for macroeconomic analysis, both in the short and in the long run.
- TFP growth is defined as the change in real output that cannot be attributed to changes in factor inputs (Solow, 1957).
- Computing this "Solow residual" is subject to many measurement challenges.
- In this paper, we focus on input measurement.
    - Standard datasets measure capital stocks and hours worked, but not the utilization rate of machines or the number of productive tasks undertaken during an hour of work.
    - Ignoring changes in these utilization margins leads to a biased measure of TFP growth.

TFP growth rates in a standard dataset



Source: EU and World KLEMS.

What has been done to solve the problem?

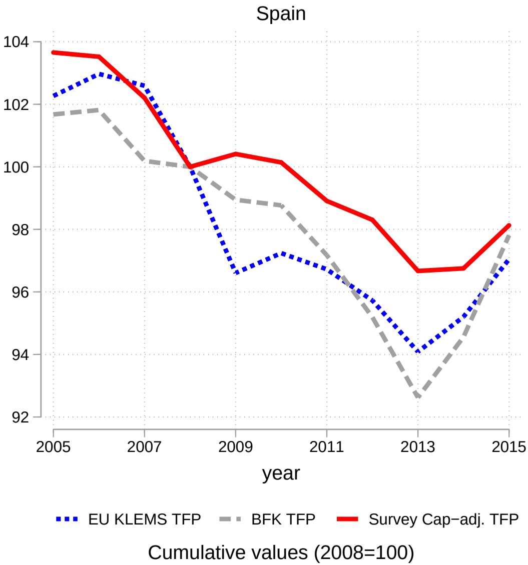
- The most successful approach is due to a series of papers by Basu, Fernald and Kimball (BFK).
- Their main insight is that cost-minimizing firms simultaneously adjust unobservable margins (utilization rate of machines, worker effort) and observable margins (hours per worker).
- Under some technical assumptions, this implies that there is a constant elasticity between the two margins: **changes in hours per worker can be used as a proxy for unobservable utilization changes.**
- Thus, adjusted TFP growth is the residual of an (industry-level) IV regression of the unadjusted Solow residual on changes in hours per worker.
  - The resulting utilization-adjusted TFP growth series for the United States have become a standard reference in macroeconomics.
  - Currently, there are no similar series for European countries.

Our contribution

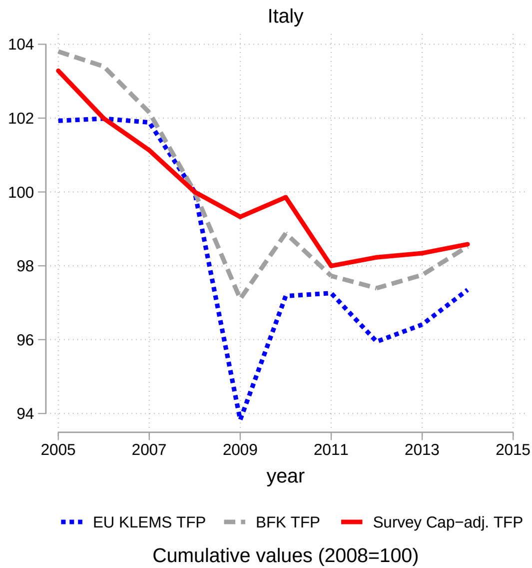
1. We argue that hours per worker are a poor utilization proxy for several countries, and propose an alternative adjustment.
    - Business cycle properties of hours per worker are different across countries.
    - Worker heterogeneity makes aggregate hours a poor proxy in some.
    - Instead, we propose to rely on direct survey data on capacity utilization.
2. We use our methodology to calculate utilization-adjusted annual TFP growth for five European countries (and for the United States).
    - Our series are less volatile and less pro-cyclical than unadjusted TFP growth series (and than TFP growth obtained with the BFK methodology).
    - They indicate a substantial increase in Southern European TFP in the first years of the Great Recession.

- Future work: dig deeper into the origins of these changes, further explore the role of adjustment costs and imperfect competition for growth accounting...

Spanish TFP around the Great Recession



Italian TFP around the Great Recession



Related literature

- **Utilization-adjusted TFP.** Solow (1957, assumed that the fraction of unused capital was equal to the unemployment rate), Costello (1993), Burnside/Eichenbaum/Rebelo (1995), Imbs (1999), Basu and Fernald (2001), Basu/Fernald/Kimball (2006), Basu/Fernald/Fisher/Kimball (2013), Fernald (2014), Levchenko and Pandalai-Nayar (2018).
- **Growth accounting.** Hulten (1978), Hall (1988), O'Mahoney and Timmer (2009), Baqaee and Farhi (2018).
- **TFP over the business cycle.** Caballero and Hammour (1994, 2005) Comin and Gertler (2006), Foster/Grim/Haltiwanger (2014).
- **European TFP growth.** Van Ark/O'Mahoney/Timmer (2008), Bloom/Sadun/Van Reenen (2012), Gopinath/Kalemli-Ozcan/ Karabarbounis/Villegas-Sanchez (2017), Schivardi and Schmitz (2018).

Outline

1. Introduction
2. Growth accounting with variable factor utilization: the BFK methodology
3. Limits of hours per worker as a utilization proxy, and an alternative
4. Data, estimation results and TFP series
5. Conclusion

The growth accounting methodology

- Assume industry i produces with $Y_{it} = Z_{it} F_i \left(K_{it}, L_{it}, M_{it} \right)$, where F_i is homogeneous of degree γ_i. Then, up to a first-order approximation,

$$dY_{it} = \frac{\partial F_i}{\partial K_{it}} \frac{K_{it}}{F_i} dK_{it} + \frac{\partial F_i}{\partial L_{it}} \frac{L_{it}}{F_i} dL_{it} + \frac{\partial F_i}{\partial M_{it}} \frac{M_{it}}{F_i} dM_{it} + dZ_{it}.$$

- The fundamental insight of growth accounting, due to Solow (1957), is that firms' cost minimization relates the production function elasticities to observable quantities.

- Consider a representative firm taking factor prices as given and carrying out a stochastic sequence of productions $\left(Y_{it} \right)_{t \in \mathbb{N}}$.

The dynamic cost minimization problem

$$\min \mathbb{E}_0 \left(\sum_{t=0}^{+\infty} \left(\prod_{s=0}^{t} \frac{1}{1+r_{is}} \right) \left(w_{it} N_{it} G_i \left(H_{it}, E_{it} \right) + P_{it}^{M} M_{it} + w_{it} N_{it} \Psi_i \left(\frac{A_{it}}{N_{it}} \right) + P_{it}^{I} K_{it} \Phi_i \left(\frac{I_{it}}{K_{it}} \right) \right) \right)$$

$$\text{such that } N_{it+1} = N_{it} + A_{it};\ K_{it+1} = (1-\delta_i) K_{it} + I_{it};\ Y_{it} = Z_{it} F_i \left(K_{it}, E_{it} H_{it} N_{it}, M_{it} \right).$$

- Labour input is $E_{it} H_{it} N_{it}$, where N_{it} is employment, H_{it} is hours per worker, and E_{it} is "effort". Employment must be chosen one period in advance, and hiring and firing workers has adjustment costs Ψ_i.
- Capital K_{it} is also predetermined, and investment has adjustment costs.
- This is the same model used by BFK (2006), with one exception.
  - They model capital utilization as an independent factor with a wage cost.
  - We model it as an endogenous object, depending on all other inputs (so that it disappears in a reduced-form production function). Details

Optimality conditions

- Define the firm's mark-up μ_{it} as $\mu_{it} = {}^{P_{it}}/_{\lambda_{it}}$, where λ_{it} is the Lagrange multiplier on the production constraint.
- Then, solving the problem yields

$$\frac{\partial F_i}{\partial M_{it}} \frac{M_{it}}{F_i} = \mu_{it} \frac{P^M_{it} M_{it}}{P_{it} Y_{it}}.$$

$$\frac{\partial F_i}{\partial L_{it}} \frac{L_{it}}{F_i} = \mu_{it} \frac{w_{it} N_{it} G_i \left(H_{it}, E_{it}\right) + w_{it} N_{it} \Psi_i \left(\frac{A_{it}}{N_{it}}\right) + \frac{1}{1+r_{it}} N_{it+1} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial N_{it+1}}\right) - N_{it} \mathbb{E}_t \left(\frac{\partial V_{it}}{\partial N_{it}}\right)}{P_{it} Y_{it}}.$$

$$\frac{\partial F_i}{\partial K_{it}} \frac{K_{it}}{F_i} = \mu_{it} \frac{P^I_{it} K_{it} \Phi_i \left(\frac{I_{it}}{K_{it}}\right) + \frac{1}{1+r_{it}} K_{it+1} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial K_{it+1}}\right) - K_{it} \mathbb{E}_t \left(\frac{\partial V_{it}}{\partial K_{it}}\right)}{P_{it} Y_{it}}.$$

- Optimizing firms set the elasticity of the production function equal to the cost share of the respective input (which is the mark-up times the sales share). Details on first-order conditions

Further simplifications

- Assume the industry is close to a BGP where marginal and actual adjustment costs are zero. We can then use the BGP values in our approximation:

$$\frac{\partial F_i}{\partial L_i^*}\frac{L_i^*}{F_i} = \mu_i^* \frac{w_i N_i^* G_i\left(H_i^*, E_i^*\right)}{P_i^* Y_i^*} \equiv \mu_i^* s_{Li}^*.$$

$$\frac{\partial F_i}{\partial K_i^*}\frac{K_i^*}{F_i} = \mu_i^* \frac{\left(r_i^* + \delta_i\right) P_i^{I*} K_i^*}{P_i^* Y_i^*} \equiv \mu_i^* s_{Ki}^*.$$

- Our measurement equation becomes

$$dY_{it} = \gamma_i \left(s_{Ki}^* dK_{it} + s_{Li}^* \left(dN_{it} + dH_{it} + dE_{it}\right) + s_{Mi}^* dM_{it}\right) + dZ_{it},$$

  where we used the additional assumption that there are no pure profits (implying $s_{Ki}^* = 1 - s_{Li}^* - s_{Mi}^*$ and $\gamma_i = \mu_i^*$).
- Finally, aggregate TFP growth is given by Hulten's theorem:

$$dZ_t = \sum_{i=1}^{I} \frac{P_{it} Y_{it}}{P_t Y_t} dZ_{it}.$$

Using hours to proxy for effort

- Worker effort is typically unobservable.
- To deal with this problem, note that the first-order conditions on hours and effort imply

$$\frac{\partial G_i}{\partial H_{it}} \frac{H_{it}}{G_i} = \frac{\partial G_i}{\partial E_{it}} \frac{E_{it}}{G_i}.$$

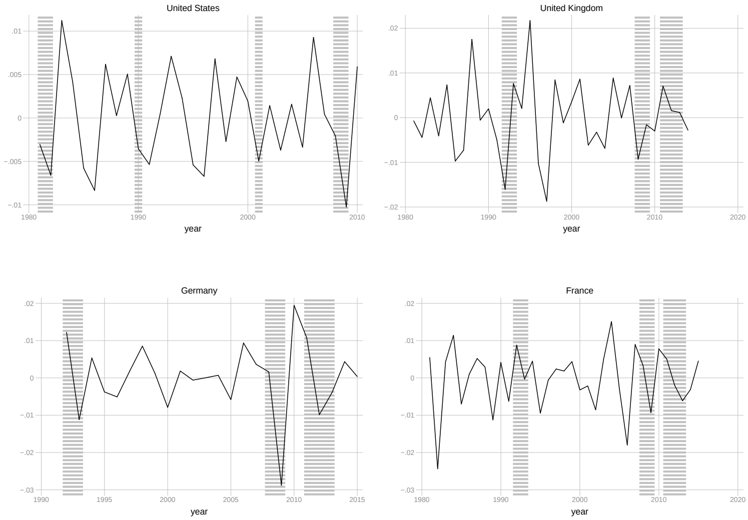
- This implies (under some mild conditions on G_i) that up to a first-order approximation, $dE_{it} = \zeta_i dH_{it}$. Then,

$$dY_{it} = \gamma_i dX_{it} + \beta_i dH_{it} + dZ_{it},$$

$$\text{where } dX_{it} = s^*_{Ki} dK_{it} + s^*_{Li} (dN_{it} + dH_{it}) \text{ and } \beta_i \equiv s^*_{Li} \zeta_i.$$

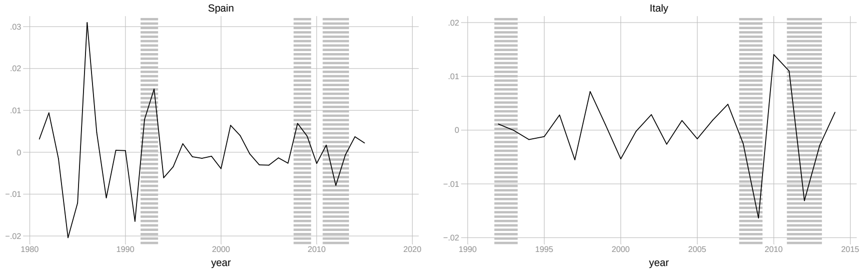
- β_i and γ_i are not observable, but they can be estimated.
  - This requires instrumenting dX_{it} and dH_{it}, as OLS has a simultaneity problem.

Hours per worker and the business cycle



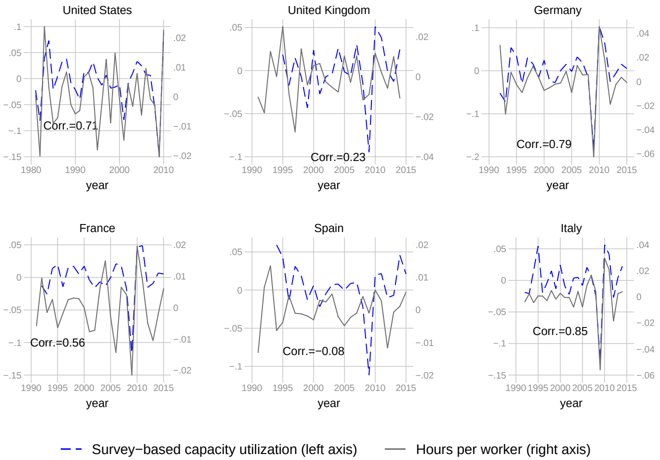
Changes in the cyclical component of $\ln\left(\text{Hours}/\text{Worker}\right)$, detrended with a band-pass filter isolating frequencies between 2 and 8 years.

Hours per worker and the business cycle



- In some countries, hours per worker are strongly procyclical (US, DE, IT). In others (ES, UK and maybe FR), this is not true.
- Given that we expect factor utilization to fall in recessions, this is a first warning sign.
- For further evidence, we compare hours per worker to direct evidence coming from capacity utilization surveys.
  - In Europe, these surveys ask (mainly in manufacturing): *"At what capacity is your company currently operating (as a percentage of full capacity)?"*

Hours per worker and capacity utilization in manufacturing



Changes in hours per worker are computed as before (for manufacturing). Changes in survey-based capacity utilization are log changes of the manufacturing survey average.

Hours per worker and capacity utilization in manufacturing

- In countries where hours per worker are procyclical, they are also highly correlated with the survey.
- In others (ES, UK), the two variables are virtually uncorrelated.
  - Most striking in the Great Recession, where hours per worker slightly increase in Spain and barely fall in the United Kingdom.
- When hours per worker and the survey disagree, which one is preferable?
  - The survey is more in line with independent evidence about the Great Recession.
  - The survey is administered in the same way everywhere (except for the US), it is hard to see why it would be a good indicator in some countries and not in others. However, it is easy to see how differences in labour market institutions could affect the cyclicality of hours per worker and bias the BFK approach.

$\Rightarrow$ We can dig a bit deeper into this using the example of Spain.

A model with worker heterogeneity

- Consider extending our model to two types of labour, permanent and temporary. Then, the measurement equation becomes

$$dY_{it} = \gamma_i dX_{it} + \beta_i^P dH_{it}^P + \beta_i^T dH_{it}^T + dZ_{it},$$

while BFK have

$$dY_{it} = \gamma_i dX_{it} + \beta_i dH_{it} + \chi_{it} + dZ_{it}.$$

- The BFK bias χ_{it} is zero iff

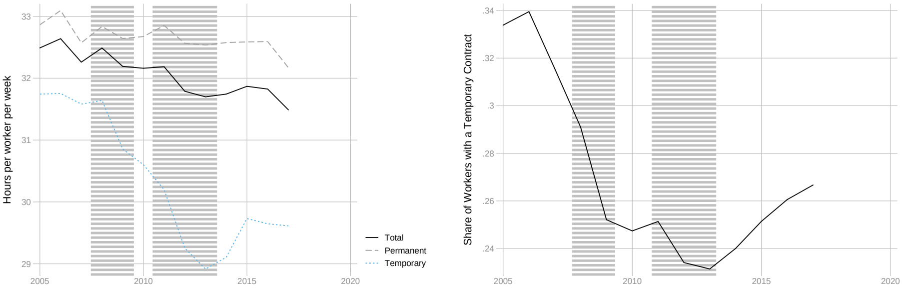
$$\beta_i \left(\frac{\omega_i^{P*} H_i^{P*}}{H_i^*} dH_{it}^P + \frac{\omega_i^{T*} H_i^{T*}}{H_i^*} dH_{it}^T + \frac{\omega_i^{P*} \left(H_i^{P*} - H_i^{T*} \right)}{H_i^*} d\omega_{it}^P \right) = \beta_i^P dH_{it}^P + \beta_i^T dH_{it}^T.$$

where $\omega_{it}^P = \frac{N_{it}^P}{N_{it}^P + N_{it}^T}$. This holds iff

1. There are no composition changes in employment ($d\omega_{it}^P = 0$) and/or steady-state hours are the same ($H_i^{P*} = H_i^{T*}$).
2. Hours for both types fluctuate symmetrically (dH_{it}^P is a linear function of dH_{it}^T).

Evidence for worker heterogeneity in Spain

- Both assumptions are violated in the Spanish data.



Source: Bank of Spain.

Our alternative utilization adjustment

- We propose to adjust for factor utilization using the direct survey evidence.
- If there is a stable relation between changes in the survey dS_{it} and unobserved changes in worker effort dE_{it},

$$dY_{it} = \gamma_i dX_{it} + \beta_i^S dS_{it} + dZ_{it},$$

- As in BFK, we estimate coefficients using IV.
  1. We impose $\gamma_i = 1$ (constant returns to scale), and restrict β_i to be equal across three broad sectors: durable and non-durable manufacturing, and non-manufacturing.
  2. Capacity utilization data for services is only available from 2011 onward (for Europe). Given the high correlation between the service and manufacturing series for the overlapping sample, we
     1. Use service data whenever available, and backcast the series for the rest of the sample by projecting on the manufacturing average (baseline)
     2. Use the manufacturing average throughout. Correlations
  3. BFK detrend hours per worker. As the survey series has no trend, except in the US, we do not detrend. Capacity levels

Data: Growth Accounting

- We use industry-level growth accounting data from different vintages of EU KLEMS (for the five largest European economies) and World KLEMS (for the US).
  - Time coverage varies by country, ranging between 1947-2010 for the US to 1991-2015 for Germany and Italy.
  - For European countries, we sometimes merge data from different vintages of the dataset, following the instructions of the KLEMS website.
- We focus on the market economy, excluding sectors such as public administration, health and education. We also exclude agriculture and mining.
  - This leaves us with 19 distinct industries.
- Note that KLEMS considers 31 inputs (3 types of intermediates, 10 types of capital, 18 types of labour).

Data: Capacity Utilization Surveys

- Europe: Harmonised Business and Consumer Surveys (EC).
  - Quarterly question for manufacturing firms: *"At what capacity is your company currently operating (as a percentage of full capacity)?"*. Results are reported for 24 industries, since 1991.
  - Since 2011, service firms answer the question "*If the demand addressed to your firm expanded, could you increase your volume of activity with your present resources? If so, by how much?*", from which an implied utilization rate is calculated.
- US: Federal Reserve Board.
  - The Fed bases its numbers mainly on the Census Bureau's Quarterly Survey of Plant Capacity. Plants report current production and full production capacity, defined as "*the maximum level of production that this establishment could reasonably expect to attain under normal and realistic operating conditions fully utilizing the machinery and equipment in place*".
  - Annual data for 17 manufacturing industries between 1972-2010.
- For both datasets, we aggregate to the KLEMS manufacturing industries using value added weights.

Data: Instruments

1. Oil price shocks.
    - Quarterly shocks are the log difference between the current real oil price and the highest real oil price in the preceding four quarters.
2. Monetary Policy shocks
    - For EMU countries, we rely on Jarocinski and Karadi (2018), who identify surprise movements in Eonia interest rate swaps after ECB announcements. For the UK, Cesa-Bianchi et al. (2018) produce a very similar series.
    - For the United States, we use Romer and Romer (2004), as updated in Wieland and Yang (2016).
3. Financial conditions
    - We use the excess bond premium of Gilchrist and Zakrajsek (2012) which is the difference between the spread of corporate unsecured bonds of US firms and the predicted spread based on firm and bond characteristics.

- For each shock, annual values are the average of quarterly (or monthly) ones. We use the shock in year $t-1$ as an instrument for utilization in year t.

Results for hours per worker as a utilization proxy

	United States			United Kingdom		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	0.636	1.352**	0.353	1.401**	-0.0790	-1.211
	(0.451)	(0.586)	(0.879)	(0.696)	(0.439)	(1.084)
Observations	115	161	207	105	105	189
First-stage Fstat	7.587	5.559	1.327	1.280	0.571	0.446

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)

UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses. Observations: Industry x year

	Germany			France		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	0.750***	0.657***	0.899**	0.700***	0.250	0.417
	(0.0924)	(0.140)	(0.397)	(0.176)	(0.231)	(0.335)
Observations	120	120	216	120	120	216
First-stage Fstat	70.66	45.95	21.49	42.01	17.93	9.898

DE: 1992-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

FR: 1992-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses. Observations: Industry x year

Results for hours per worker as a utilization proxy

	Spain			Italy		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	2.604*	-2.663	-1.566	0.660***	0.727***	-0.0573
	(1.362)	(3.879)	(1.055)	(0.0772)	(0.167)	(0.423)
Observations	115	115	207	115	115	207
Creaig-Davis F-stat	1.153	0.203	3.233	57.67	28.09	6.639

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1992-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry × year

- For high-correlation countries (US, DE, IT), the results appear overall satisfying (but note that coefficients differ across countries).
- For countries in which hours were not correlated with the survey (ES, UK), the regressions "do not work".
  - Many estimates are negative, contrary to the spirit of the BFK methodology.
  - Instruments are generally weak.

Results for the survey as a utilization proxy

	United States			United Kingdom		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.178**	0.219*	0.0523	0.142***	-0.0645	0.139***
	(0.0839)	(0.115)	(0.109)	(0.0416)	(0.101)	(0.0534)
Observations	115	161	207	100	100	180
First-stage Fstat	10.54	12.58	36.24	35.42	6.223	82.76

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)

UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses.

Observations: Industry x year

Not detrended survey data for capacity utilization

	Germany			France		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.297***	0.464***	0.197*	0.174***	0.120*	0.116***
	(0.0367)	(0.0660)	(0.106)	(0.0508)	(0.0658)	(0.0348)
Observations	120	120	216	120	120	216
First-stage Fstat	47.59	17.02	57.01	45.46	30.15	152.0

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses.

Observations: Industry x year

Not detrended survey data for capacity utilization

Results for the survey as a utilization proxy

	Spain			Italy		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.180***	0.153***	0.183*	0.285***	0.373***	0.169***
	(0.0338)	(0.0519)	(0.0968)	(0.0285)	(0.0843)	(0.0613)
Observations	110	110	198	115	115	207
Creaig-Davis F-stat	14.38	13.38	62.58	45.28	15.55	63.19

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

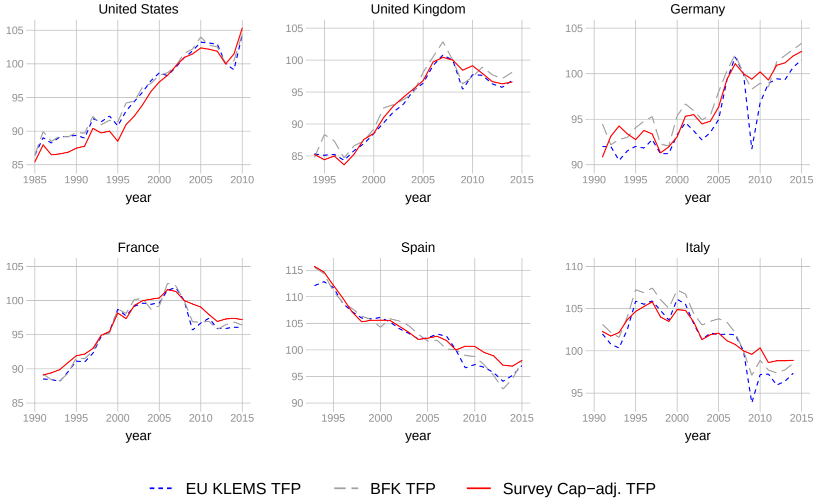
Robust standard errors in parentheses.

Observations: Industry x year

Not detrended survey data for capacity utilization

- The survey regressions perform much better.
  - With the exception of the UK non-durable manufacturing sector, all coefficients are positive and instruments are no longer weak.
  - Coefficients are in general quite similar across countries.
- What do these estimations imply for TFP growth rates?

Utilization-adjusted TFP levels



Cumulative values (2008=100)

TFP in Southern Europe

- Southern European countries such as Italy or Spain had low TFP growth since the middle of the 1990s.
- The KLEMS data suggested that the TFP decline continued through the crisis.
- Our measure suggests, instead, that the trend was interrupted during the first years of the Great Recession, especially in Spain.
  - Is this evidence for selection/cleansing at the micro-level?
  - Need firm-level data to answer this question.

Means and variances

United States	1985-2010		**United Kingdom**	1994-2015	
	Mean	SD		Mean	SD
VA	2.56	2.56	VA	2.27	2.50
TFP_{KLEMS}	0.72	1.62	TFP_{KLEMS}	0.57	1.68
TFP_{BFK}	0.72	1.55	TFP_{BFK}	0.67	2.09
TFP_{Survey}	0.80	1.38	TFP_{Survey}	0.57	1.37
Germany	1991-2015		**France**	1991-2015	
	Mean	SD		Mean	SD
VA	1.11	3.05	VA	1.63	2.11
TFP_{KLEMS}	0.40	2.50	TFP_{KLEMS}	0.32	1.53
TFP_{BFK}	0.37	1.62	TFP_{BFK}	0.30	1.61
TFP_{Survey}	0.48	1.26	TFP_{Survey}	0.34	1.00
Spain	1993-2015		**Italy**	1991-2014	
	Mean	SD		Mean	SD
VA	1.81	3.00	VA	0.65	2.80
$TFP_{EU\ KLEMS}$	-0.68	1.32	$TFP_{EU\ KLEMS}$	-0.20	2.04
TFP_{BFK}	-0.81	1.50	TFP_{BFK}	-0.20	1.54
TFP_{Survey}	-0.80	1.07	TFP_{Survey}	-0.15	0.98

Correlations

United States	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.656	1		
BFK	0.439	0.891	1	
Survey Cap-adj.	0.367	0.889	0.896	1

United Kingdom	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.821	1		
BFK	0.685	0.738	1	
Survey Cap-adj.	0.510	0.811	0.587	1

Germany	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.934	1		
BFK	0.347	0.573	1	
Survey Cap-adj.	0.267	0.450	0.611	1

Correlations

	France			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.821	1		
BFK	0.628	0.907	1	
Survey Cap-adj.	0.440	0.747	0.817	1

	Spain			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.481	1		
BFK	0.270	0.519	1	
Survey Cap-adj.	0.0280	0.538	0.614	1

	Italy			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.809	1		
BFK	0.634	0.906	1	
Survey Cap-adj.	0.295	0.591	0.777	1

Assessment

- The adjusted TFP series are
  1. Less volatile than the unadjusted ones.
  2. Less procyclical than the adjusted ones.
- With respect to the series obtained with the BFK methodology,
  1. Our adjusted TFP series is considerably less volatile.
  2. The correlation is, by construction, higher in countries where hours and the survey are more highly correlated (most strikingly, in Germany).
  3. It is lowest in Spain and in the United Kingdom, where it gives a very different picture of TFP fluctuations.

Conclusions

- We have shown that using hours per worker as a proxy for factor utilization is problematic in several European countries.
- We propose an alternative adjustment method, based on survey data on capacity utilization, and use it to produce new utilization-adjusted TFP series.
- There are many things left to do!
  1. Quarterly data series.
  2. Explore the role of firm and worker-level selection in generating Southern European TFP movements during the Great Recession.
  3. Explore the role of adjustment costs for growth accounting when industries are not on a BGP.
  4. Take into account the role of frictions (in particular, imperfect competition).

Detailed Assumptions

- The adjustment costs functions G_i, Ψ_i and Φ_i are increasing and convex in all arguments. Furthermore, they hold

$$\Psi_i(0) = \Psi_i'(0) = 0$$

$$\Phi_i(\delta_i) = \delta_i \text{ and } \Phi_i'(\delta_i) = 1.$$

- The production function with capacity utilization can be written as $\widetilde{F}_i(U_{it}K_{it}, L_{it}, M_{it})$.
  - We assume that the utilization rate U_{it} depends on all other inputs, so that $U_{it} = \Gamma_i(K_{it}, L_{it}, M_{it})$.
  - Therefore, we can subsume it in the reduced-form production function F_i (without needing to specify a functional form for Γ_i).

Back

First-order conditions

- Adjustable factors

$$w_{it} N_{it} \frac{\partial G_i}{\partial H_{it}} = \lambda_{it} Z_{it} \frac{\partial F_i}{\partial L_{it}} E_{it} N_{it}$$

$$w_{it} N_{it} \frac{\partial G_i}{\partial E_{it}} = \lambda_{it} Z_{it} \frac{\partial F_i}{\partial L_{it}} H_{it} N_{it}$$

$$P_{it}^{M} = \lambda_{it} Z_{it} \frac{\partial F_i}{\partial M_{it}}$$

- Hiring and investment

$$w_{it} \Psi_i' \left(\frac{A_{it}}{N_{it}} \right) + \frac{1}{1 + r_{it}} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial N_{it+1}} \right) = 0$$

$$P_{it}^{I} \Phi_i' \left(\frac{I_{it}}{K_{it}} \right) + \frac{1}{1 + r_{it}} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial K_{it+1}} \right) = 0$$

Back

Envelope conditions

$$\frac{\partial V_{it}}{\partial N_{it}} = \begin{array}{c} w_{it} G_i \left(H_{it}, E_{it} \right) + w_{it} \Psi_i \left(\frac{A_{it}}{N_{it}} \right) - w_{it} \frac{A_{it}}{N_{it}} \Psi_i' \left(\frac{A_{it}}{N_{it}} \right) \\ -\lambda_{it} Z_{it} \frac{\partial F_i}{\partial L_{it}} E_{it} H_{it} + \frac{1}{1+r_{it}} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial N_{it+1}} \right), \end{array},$$

$$\frac{\partial V_{it}}{\partial K_{it}} = P^I_{it} \Phi_i \left(\frac{A_{it}}{N_{it}} \right) - P^I_{it} \frac{I_{it}}{K_{it}} \Phi_i' \left(\frac{A_{it}}{N_{it}} \right) - \lambda_{it} Z_{it} \frac{\partial F_i}{\partial K_{it}} + \frac{1-\delta_i}{1+r_{it}} \mathbb{E}_t \left(\frac{\partial V_{it+1}}{\partial K_{it+1}} \right).$$

Back

Capacity utilization in services and manufacturing

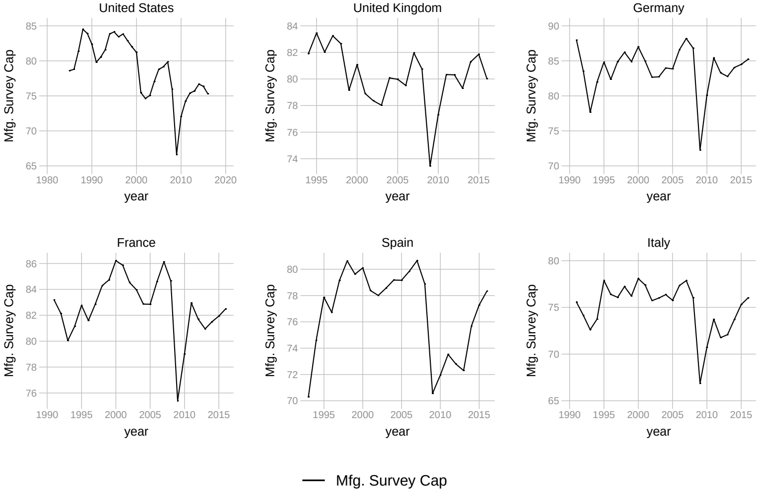
- Service industries have utilization data only from 2011 onward, but these series are highly correlated with the manufacturing average.

	United Kingdom	Germany	France	Spain	Italy
Correlation coeff.	0.61	0.75	0.68	0.83	0.67
Observations	25	27	24	25	31

Notes: Correlation coefficients between the quarter-on-quarter growth rates of average capacity utilization in service industries and average capacity utilization in manufacturing industries.

Back

Capacity utilization levels



Notes: Average level of capacity utilization in manufacturing industries. Back