The Vanishing Procyclicality of Labor Productivity

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Appendices
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A Additional Business Cycle Statistics for the US

Table 5. Additional Business Cycle Statistics

A. Volatility output and productivity

	Std. Dev.			Relative Std. Dev.		
	Pre-84	Post-84	Ratio	Pre-84	Post-84	Ratio
Output						
BP	2.53	1.39	0.55			
	[0.13]	[0.09]	[0.05]			
4D	3.95	2.24	0.57			
	[0.20]	[0.28]	[0.08]			
HP	2.59	1.47	0.57			
	[0.14]	[0.10]	[0.05]			
Output per worker						
BP	1.49	0.83	0.56	0.59	0.60	1.02
	[0.08]	[0.05]	[0.05]	[0.03]	[0.05]	[0.09]
4D	2.54	1.40	0.55	0.64	0.63	0.97
	[0.13]	[0.08]	[0.04]	[0.03]	[0.08]	[0.13]
HP	1.57	0.89	0.56	0.61	0.60	0.99
	[0.08]	[0.07]	[0.05]	[0.03]	[0.05]	[0.10]

B. Correlations

	Corr with output			Corr with employment		
	Pre-84	Post-84	Change	Pre-84	Post-84	Change
Employment (private sector)						
BP	0.83	0.80	−0.02			
	[0.02]	[0.03]	[0.04]			
4D	0.78	0.79	0.01			
	[0.03]	[0.05]	[0.06]			
HP	0.81	0.82	0.01			
	[0.03]	[0.03]	[0.04]			

Standard errors in brackets are calculated from the variance-covariance matrix of the second moments using the delta method. See tables 1 and 2 for data sources and sample period.

B International Evidence

Although in this paper we focus on the US, it is worth exploring whether the same patterns hold for other countries as well. For many countries, data are not available for our sample period. However, Ohanian and Raffo (2012) collected data on output, employment and hours worked from the OECD Economic Outlook database and national statistics offices, for many countries starting from 1960. Table 6 reports the cyclicality of labor productivity and the relative volatility of labor input for the four major European economies using these data. For comparison, we also report the statistics for the US over the same period.

The change in labor market dynamics in the US is much more pronounced than in almost all other countries. In fact, the drop in the procyclicality of labor productivity in the US looks even more dramatic over the 1960-2013 period than over our baseline period (1948-2015). In the majority of other countries, the procyclicality of labor productivity decreases much less, or even increases slightly. Notable exceptions are Spain, and to a lesser degree also Ireland, Sweden and perhaps Norway and the UK, where the procyclicality of labor productivity also declined substantially.

Next, we look at the change in labor market turnover in these countries, using international time series data for worker flows calculated by Elsby, Hobijn, and Şahin (2013). Unfortunately, for most countries these data start only in 1983, so that the best we can do is to compare the 1985-90 period to the 2002-2007 period. These statistics are reported in (the left-hand side panel of) Table 7.

The US is the country with by far the largest decline in the separation rate, followed at a distance by Ireland. Other countries not only experience a much smaller (or no) decline in turnover, but the level of the separation rate is much lower as well, which –with quadratic adjustment costs– implies that even for the same decline in turnover the effect on frictions would be much smaller. Therefore, in light of the explanation we propose in this paper, it should not be surprising that labor productivity became much less procyclical in the US, whereas there was no such change in many other countries.

Finally, how is it possible that the dynamics of productivity, output and employment in Spain (and Sweden, Norway and the UK) changed as much as it did, whereas there is no evidence for a decline in labor market turnover in these countries? We argue the reason is simply that there were other changes than the separation rate affecting labor market frictions. The decline in turnover may have been the main driver of the reduction in labor market frictions in the US, but other countries, like Spain, experienced a huge liberalization of the labor market over this period, which reduced frictions for entirely different reasons. Comparing the OECD employment protection index for the same countries and the same time periods as the separation rates (right-hand side panel of Table 7), we see that Spain is with distance the country that experienced the greatest change in employment protection.

Table 6. Changes in Labor Market Dynamics in European and other OECD Countries, 1960-2013

	Correlation Productivity						Relative Std. Dev.		
	with output			with employment			employment		
	Pre-84	Post-84	Change	Pre-84	Post-84	Change	Pre-84	Post-84	Ratio
US, baseline	0.78	0.60	−0.18	0.31	−0.15	−0.47	0.66	0.81	1.23
US, OR	0.76	0.48	−0.28	0.25	−0.20	−0.45	0.67	0.90	1.33
Austria	0.83	0.86	0.02	−0.15	0.34	0.49	0.56	0.55	0.99
Finland	0.68	0.73	0.05	−0.25	−0.08	0.17	0.76	0.69	0.91
France	0.93	0.85	−0.08	0.42	0.31	−0.11	0.40	0.56	1.38
Germany	0.86	0.92	0.07	0.31	0.28	−0.02	0.54	0.40	0.74
Ireland	0.87	0.61	−0.26	−0.17	−0.33	−0.16	0.50	0.84	1.66
Italy	0.93	0.82	−0.11	0.35	0.02	−0.33	0.40	0.58	1.43
Norway	0.87	0.58	−0.29	−0.41	−0.43	−0.02	0.53	0.90	1.70
Spain (1961-)	0.72	−0.06	−0.78	−0.25	−0.57	−0.31	0.47	1.20	2.54
Sweden	0.83	0.64	−0.19	0.01	−0.19	−0.20	0.55	0.78	1.42
UK	0.92	0.81	−0.11	−0.05	−0.10	−0.04	0.40	0.59	1.49
Australia (1964-)	0.65	0.50	−0.15	−0.34	−0.57	−0.23	0.73	1.04	1.43
Canada	0.44	0.83	0.40	−0.27	0.21	0.48	0.94	0.56	0.60
Japan	0.95	0.96	0.02	0.16	0.34	0.18	0.32	0.29	0.89
Korea (1970-)	0.93	0.80	−0.13	−0.03	0.40	0.44	0.35	0.65	1.85

All data are bandpass filtered and refer to the private sector. Data for the baseline results for the US are from the BLS labor productivity and cost program (LPC), see Tables 1, 2 and 3 for details. Data for all other countries were collected by Ohanian and Raffo (2012) from the OECD Economic Outlook database and national statistics offices. For consistency with our baseline results, productivity is real output per worker and employment is in persons, although the Ohanian-Raffo data also allow to calculate output per hour and total hours.

Table 7. Changes in Labor Market Institutions in European and other OECD Countries, 1985-2007

	Separation rate				Employment protection			
	1985-90	2002-07	Change	Ratio	1985-90	2002-07	Change	Ratio
US	3.8	2.9	−0.9	0.76	25.7	25.7	0.0	1.00
Austria					275.0	244.5	−30.5	0.89
Finland					278.6	216.7	−61.9	0.78
France	0.8	0.8	0.0	1.00	242.4	244.3	1.8	1.01
Germany	0.4	0.6	0.2	1.41	258.3	279.3	21.0	1.08
Ireland	0.7	0.4	−0.3	0.56	143.7	140.4	−3.3	0.98
Italy	0.4	0.4	0.0	1.11	276.2	276.2	0.0	1.00
Norway	1.2	1.8	0.6	1.47	233.3	233.3	0.0	1.00
Spain	0.9	0.9	0.0	0.99	354.8	235.7	−119.1	0.66
Sweden	0.8	1.4	0.7	1.84	279.8	260.7	−19.1	0.93
UK	0.9	0.9	0.0	1.11	103.2	119.8	16.6	1.16
Australia	1.7	1.8	0.1	1.04	116.7	141.7	25.0	1.21
Canada	2.3	2.5	0.2	1.09	92.1	92.1	0.0	1.00
Japan	0.5	0.8	0.2	1.44	170.2	170.2	0.0	1.00
Korea						236.9		

Data for the separation rate are from Elsby, Hobijn, and Şahin (2013). Employment protection is the EPRC index (version 1) from the OECD. The begin and end year of the sample were chosen to obtain consistent results for both the separation rates and the employment protection index for as many countries as possible, while spanning a time period that is as close as possible to the results on labor market dynamics. The EHS start in 1983 for most countries, and run to 2007 (actually, they were updated to 2013, but I cannot read the updated Excel file that is available online). Data on employment protection run from 1985 to 2013. The index is very persistent over time, so changing the end year of the sample would make very little difference.

C Marginal Product and Disutility of Effort

This appendix derives the marginal product of employment to the firm, equation (12), and the marginal disutility from employment, expressed in consumption terms, to the household, equation (16), if effort adjusts endogenously. From equations (4) and (2), it is straightforward differentation to decompose the total effect of employment on output and total effective labor supply into a direct effect and an effect through the endogenous response of effort.

$$\frac{dY_{jt}}{dN_{jt}} = \frac{\partial Y_{jt}}{\partial N_{jt}} + \frac{\partial Y_{jt}}{\partial \mathcal{E}_{jt}} \frac{\partial \mathcal{E}_{jt}}{\partial N_{jt}} = \frac{(1-\alpha) Y_{jt}}{N_{jt}} \left(1 + \psi \frac{N_{jt}}{\mathcal{E}_{jt}} \frac{\partial \mathcal{E}_{jt}}{\partial N_{jt}} \right) \tag{36}$$

$$\frac{dL_{ht}}{dN_{ht}} = \frac{\partial L_{ht}}{\partial N_{ht}} + \frac{\partial L_{ht}}{\partial \mathcal{E}_{ht}} \frac{\partial \mathcal{E}_{ht}}{\partial N_{ht}} = \frac{1}{1+\zeta} \left[1 + \zeta \mathcal{E}_{ht}^{1+\phi} \left(1 + (1+\phi) \frac{N_{ht}}{\mathcal{E}_{ht}} \frac{\partial \mathcal{E}_{ht}}{\partial N_{ht}} \right) \right] \tag{37}$$

Here, $\mathcal{E}_{jt}$ denotes the effort of all workers i that are employed in firm j and $\mathcal{E}_{ht}$ the effort of all workers that are members of household h.

To find the response of effort to changes in employment that firm and household face, we use the condition that the marginal disutility from effort of a given worker i (expressed in consumption terms) from equation (8), in equilibrium must equal the marginal productivity of that worker to the firm from equation (9).

$$\mathcal{E}_{it}^{1+\phi-\psi} = \frac{\psi (1+\zeta)}{(1+\phi)\zeta} \frac{Z_t}{\gamma C_{ht}^{\eta}} (1-\alpha) A_t \left(\int_0^{N_{jt}} \mathcal{E}_{vt}^{\psi} dv \right)^{-\alpha} \tag{38}$$

First, suppose firm j considers employing N_{jt} workers, given that all other firms employ the equilibrium number of workers N_t. Because there are infinitely many firms, firm j's decision to employ $N_{jt} \neq N_t$ workers does not affect the fraction of household h's members that are employed, so that by the assumption of perfect risk-sharing within the household, the consumption of workers in firm j is not affected, $C_{ht} = C_t$. Substituting this, as well as the condition that all workers in firm j exert the same amount of effort, $\mathcal{E}_{it} = \mathcal{E}_{jt}$ for all $i \in [0, N_{jt}]$, the effort condition becomes,

$$\mathcal{E}_{jt}^{1+\phi-\psi} = \frac{\psi (1+\zeta)}{(1+\phi)\zeta} \frac{Z_t}{\gamma C_t^{\eta}} (1-\alpha) A_t \left(\mathcal{E}_{jt}^{\psi} N_{jt} \right)^{-\alpha} \tag{39}$$

so that the elasticity of effort in a given firm j with respect to employment in that firm, is given by

$$\frac{N_{jt}}{\mathcal{E}_{jt}} \frac{\partial \mathcal{E}_{jt}}{\partial N_{jt}} = -\frac{\alpha}{1+\phi-(1-\alpha)\psi} \tag{40}$$

Substituting this elasticity into equation (36) above, gives expression (12) in the text.

Next, suppose household h considers having N_{ht} employed workers, given that all other households have N_t employed workers. Because there are infinitely many households, household's h's decision to have a fraction of $N_{ht} \neq N_t$ of its members employed, does not affect the level of employment in any firm $N_{jt} = N_t$. Furthermore, although the effort level of worker i may change because of household h's decision, effort of all other workers in firm j, who are members of different households, is unaffected, $\mathcal{E}_{it} = \mathcal{E}_{ht}$ and $\mathcal{E}_{i't} = \mathcal{E}_t$ for $i' \neq i$. Thus, the effort condition becomes,

$$\mathcal{E}_{ht}^{1+\phi-\psi} = \frac{\psi\,(1+\zeta)}{(1+\phi)\,\zeta}\frac{Z_t}{\gamma C_{ht}^{\eta}}\,(1-\alpha)\,A_t\left(\mathcal{E}_t^{\psi}N_t\right)^{-\alpha} \tag{41}$$

and the elasticity of effort exerted by members of household h with respect to employment in that household, using equation (3), is given by,

$$\frac{N_{ht}}{\mathcal{E}_{ht}}\frac{\partial\mathcal{E}_{ht}}{\partial N_{ht}} = \frac{C_{ht}}{\mathcal{E}_{ht}}\frac{\partial\mathcal{E}_{ht}}{\partial C_{ht}}\cdot\frac{N_{ht}}{C_{ht}}\frac{\partial C_{ht}}{\partial N_{ht}} = -\frac{\eta}{1+\phi-\psi}\frac{W_{ht}N_{ht}}{C_{ht}} = -\frac{\eta}{1+\phi-\psi} \tag{42}$$

Substituting this elasticity into equation (37) above, gives expression (16) in the text.

D Robustness Analysis: Additional Simulation Results

Table 8. Simulation results, less convex adjustment costs ($1 + \mu = 1.6$)

	frictions (% GDP)	empl/pop ratio $\bar{N}$	correlation productivity with output	with empl	relative std.dev. empl n_t	wage w_t	std.dev. output y_t
Data							
Pre-84			0.78	0.31	0.66	0.30	
Post-84			0.60	−0.15	0.81	0.88	
Model							
$\delta = 0.40$	3.60	0.60	0.76	−0.03	0.65	0.88	1.00
$\delta = 0.35$ (Pre)	**3.00**	0.62	0.75	−0.07	**0.66**	0.88	**1.00**
$\delta = 0.30$	2.42	0.63	0.74	−0.11	0.67	0.89	1.00
$\delta = 0.25$	1.86	0.65	0.73	−0.15	0.69	0.89	0.99
$\delta = 0.20$ (Post)	1.33	0.66	0.72	−0.18	0.70	0.89	0.99
$\delta = 0.15$	0.86	0.68	0.72	−0.21	0.71	0.89	0.98
$\delta = 0$	0.00	**0.70**	0.72	−0.25	0.72	0.90	0.97

Table 9. Simulation results, less convex adjustment costs (quadratic)

	frictions (% GDP)	empl/pop ratio $\bar{N}$	correlation productivity with output	with empl	relative std.dev. empl n_t	wage w_t	std.dev. output y_t
Data							
Pre-84			0.78	0.31	0.66	0.30	
Post-84			0.60	-0.15	0.81	0.88	
Model							
$\delta = 0.40$	3.66	0.57	0.77	0.04	0.63	0.87	1.00
$\delta = 0.35$ (Pre)	**3.00**	0.59	0.75	-0.03	**0.66**	0.87	**1.00**
$\delta = 0.30$	2.35	0.61	0.73	-0.09	0.69	0.88	1.00
$\delta = 0.25$	1.73	0.64	0.70	-0.15	0.72	0.88	0.99
$\delta = 0.20$ (Post)	1.16	0.66	0.68	-0.19	0.74	0.88	0.99
$\delta = 0.15$	0.68	0.67	0.66	-0.23	0.77	0.88	0.99
$\delta = 0$	0.00	**0.70**	0.64	-0.29	0.81	0.88	0.99

Table 10. Simulation results, more convex adjustment costs ($1 + \mu = 3.4$)

	frictions (% GDP)	empl/pop ratio $\bar{N}$	correlation productivity with output	with empl	relative std.dev. empl n_t	wage w_t	std.dev. output y_t
Data							
Pre-84			0.78	0.31	0.66	0.30	
Post-84			0.60	−0.15	0.81	0.88	
Model							
$\delta = 0.40$	3.62	0.45	0.82	0.26	0.59	0.85	0.98
$\delta = 0.35$ (Pre)	**3.00**	0.50	0.76	0.14	**0.66**	0.86	**1.00**
$\delta = 0.30$	2.31	0.54	0.67	−0.00	0.74	0.85	1.02
$\delta = 0.25$	1.60	0.59	0.55	−0.15	0.84	0.84	1.05
$\delta = 0.20$ (Post)	0.93	0.64	0.41	−0.29	0.95	0.81	1.09
$\delta = 0.15$	0.41	0.67	0.28	−0.41	1.05	0.78	1.13
$\delta = 0$	0.00	**0.70**	0.09	−0.54	1.18	0.72	1.21

Table 11. Simulation results (quadratic adjustment costs),
asymmetric Nash bargaining

	frictions (% GDP)	empl/pop ratio $\bar{N}$	correlation productivity with output	with empl	relative std.dev. empl n_t	wage w_t	std.dev. output y_t
Data							
Pre-84			0.78	0.31	0.66	0.30	
Post-84			0.60	−0.15	0.81	0.88	
Model, $\xi = 0.2$							
$\delta = 0.40$	3.77	0.62	0.77	-0.07	0.64	0.96	1.00
$\delta = 0.35$ (Pre)	**3.00**	0.64	0.75	−0.11	**0.66**	0.95	**1.00**
$\delta = 0.30$	2.28	0.65	0.74	−0.15	0.68	0.94	1.00
$\delta = 0.25$	1.64	0.67	0.73	−0.18	0.70	0.93	1.00
$\delta = 0.20$ (Post)	1.08	0.68	0.72	−0.21	0.71	0.92	0.99
$\delta = 0.15$	0.62	0.69	0.71	−0.23	0.72	0.91	0.99
$\delta = 0$	0.00	**0.70**	0.70	−0.26	0.74	0.90	0.99
Model, $\xi = 0.7$							
$\delta = 0.40$	3.51	0.47	0.79	0.21	0.63	0.74	1.00
$\delta = 0.35$ (Pre)	**3.00**	0.50	0.75	0.11	**0.66**	0.76	**1.00**
$\delta = 0.30$	1.45	0.54	0.72	0.02	0.70	0.78	1.00
$\delta = 0.25$	1.89	0.58	0.67	−0.07	0.74	0.79	1.00
$\delta = 0.20$ (Post)	1.33	0.61	0.63	−0.16	0.79	0.81	1.00
$\delta = 0.15$	0.81	0.65	0.58	−0.23	0.84	0.82	1.00
$\delta = 0$	0.00	**0.70**	0.51	−0.35	0.92	0.83	1.00

Here, we use the following expression for the flexible wage instead of equation (21)

$$W_t^* = \xi W_t^{UB} + (1 - \xi) W_t^{LB}$$

where ξ is workers bargaining power. We use values for ξ that are well out of the range of values that are commonly used in the literature, to show that this parameter is not important for our results.

Table 12. Simulation results (quadratic adjustment costs), Frisch elasticity 0.25

	frictions (% GDP)	empl/pop ratio $\bar{N}$	correlation productivity with output	with empl	relative std.dev. empl n_t	wage w_t	std.dev. output y_t
Data							
Pre-84			0.78	0.31	0.66	0.30	
Post-84			0.60	−0.15	0.81	0.88	
Model							
$\delta = 0.40$	3.76	0.64	0.77	-0.05	0.64	0.94	1.00
$\delta = 0.35$ (Pre)	**3.00**	0.65	0.75	−0.10	**0.66**	0.94	**1.00**
$\delta = 0.30$	2.29	0.66	0.74	−0.14	0.68	0.93	1.00
$\delta = 0.25$	1.64	0.67	0.73	−0.18	0.70	0.93	1.00
$\delta = 0.20$ (Post)	1.07	0.68	0.72	−0.20	0.71	0.92	1.00
$\delta = 0.15$	0.62	0.69	0.71	−0.23	0.72	0.91	1.00
$\delta = 0$	0.00	**0.70**	0.70	−0.26	0.74	0.90	1.00

Chetty, Guren, Manoli, and Weber (2012) argue based on estimates from micro-data that the Frisch elasticity of labor supply along the extensive margin is around 0.25. In our baseline specification, we use a utility function that is linear in labor supply, which amounts to a Frisch elasticity of infinity. To explore the robustness of our results, we change utility function (1),

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{Z_t C_t^{1-\eta}}{1-\eta} - \frac{\gamma L_t^{1+\theta}}{1+\theta} \right]$$

where $\theta = 0$ corresponds to our baseline specification and $\theta = 4$ to a Frisch elasticity of 0.25. This change affects the efficiency condition for effort (11) and the Bellman equation for worker surplus (17) and therefore the expression for the lower bound of the bargaining set (20). In both cases, the change amounts to replacing the MRS between consumption and leisure from $\frac{Z_t}{\gamma C_t^{\eta}}$ to $\frac{Z_t}{\gamma C_t^{\eta} L_t^{\theta}}$, where $L_t = \frac{1+\zeta \mathcal{E}_t^{1+\phi}}{1+\zeta} N_t$ is total effective labor supply. The results below are for $\theta = 4$ (and the other parameters recalibrated as appropriate). Results are very similar to the baseline calibration.