Productivity Dynamics over the Medium Term

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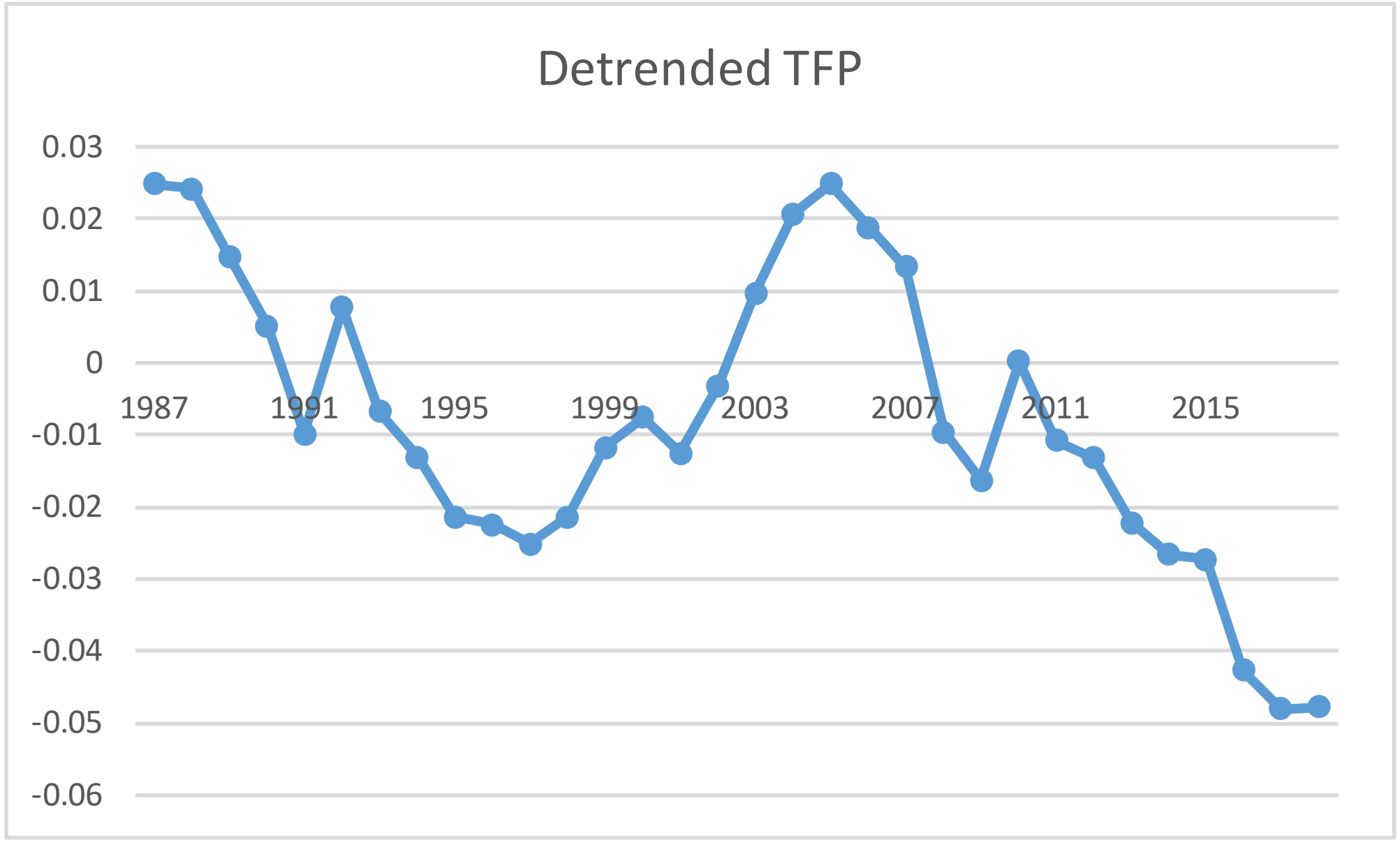
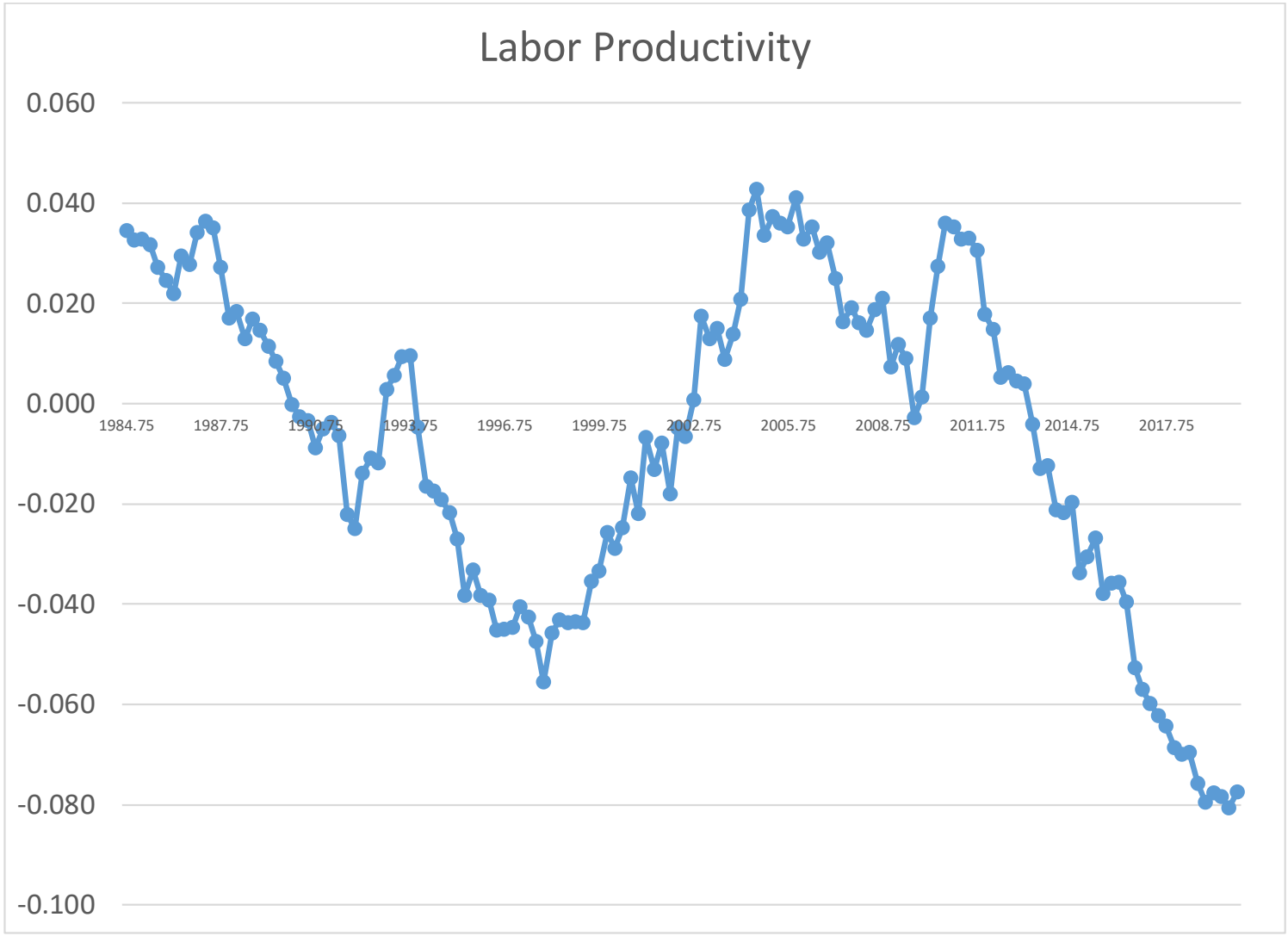
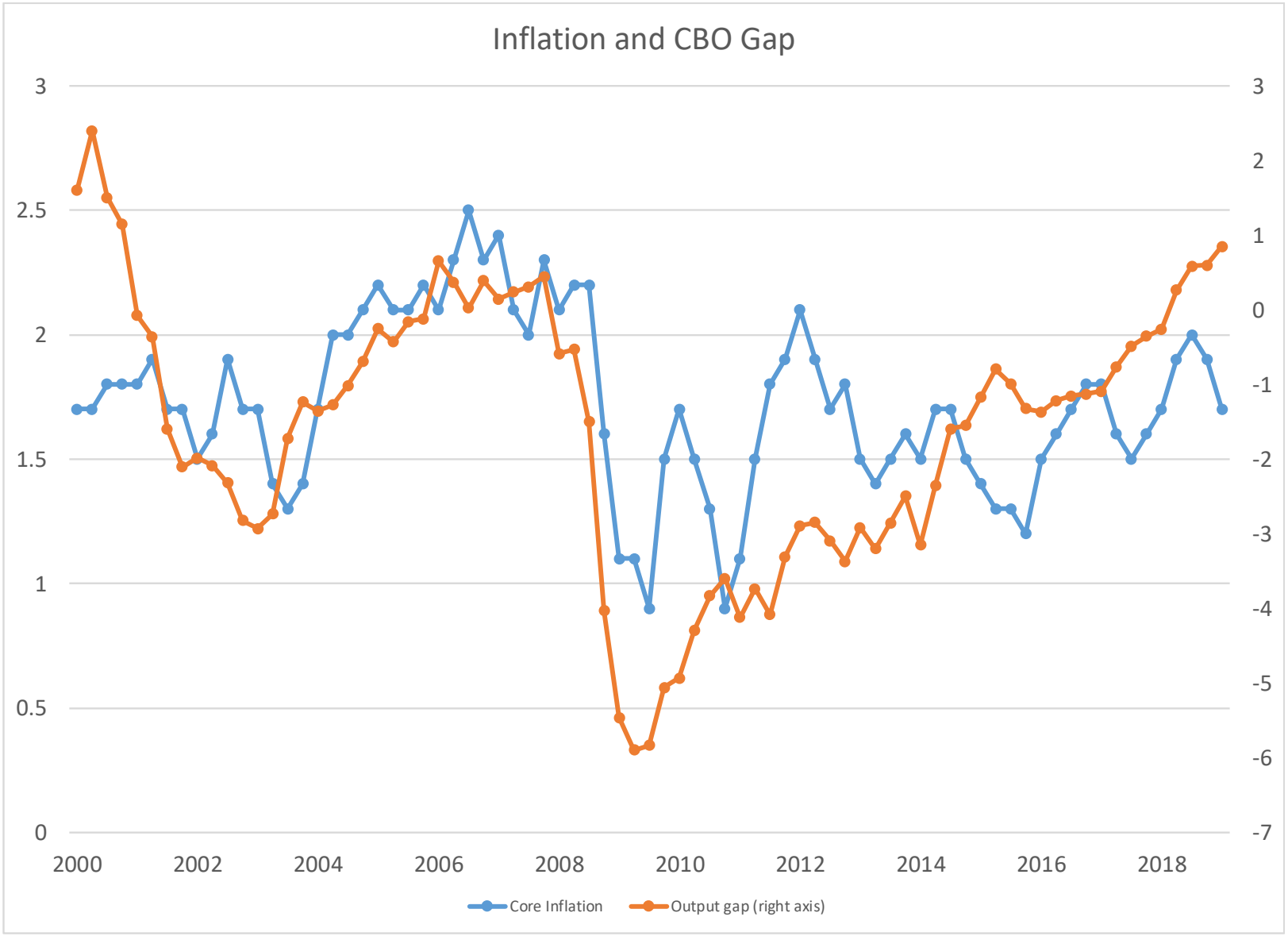
Facts about Productivity and Inflation

- Slowdown in Productivity Growth, since 2005 until recently
  - Slowdown in TFP concentrated in followers
  - Wide-spread across countries
  - Recently, TFP grows at pre-GR growth rate
- Inflation was higher than expected during and after GR
- But lower than expected once short-run output converged


Detrended TFP
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
1987
1991
1995
1999
2003
2007
2011
2015


Labor Productivity
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
1984.75
1987.75
1990.75
1993.75
1996.75
1999.75
2002.75
2005.75
2008.75
2011.75
2014.75
2017.75

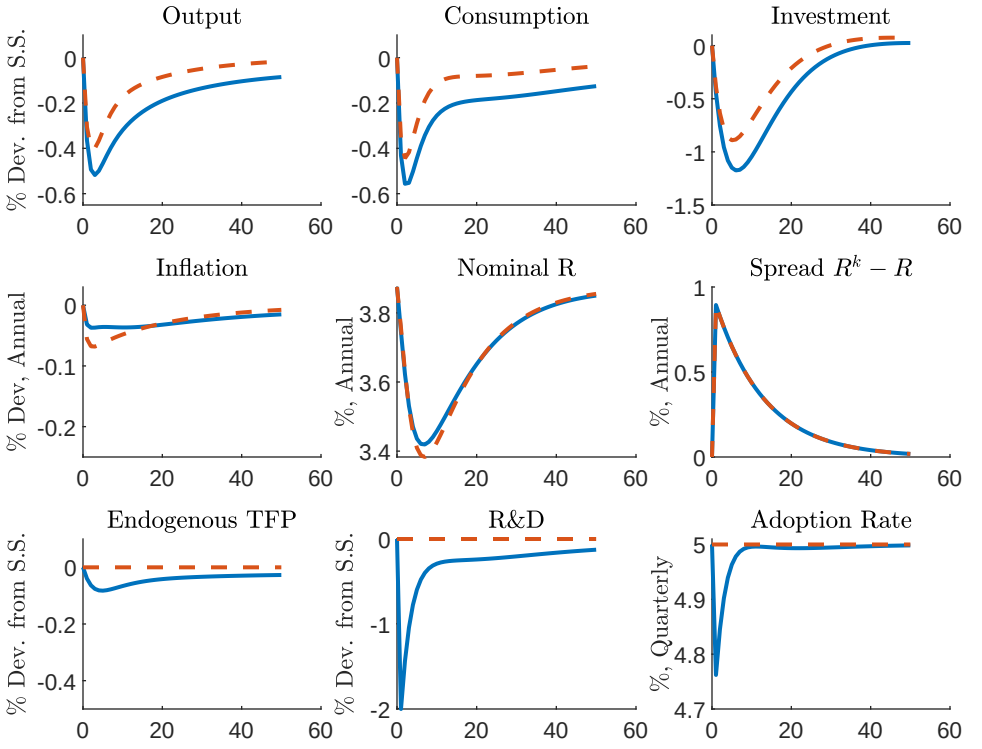

Inflation and CBO Gap
3
2.5
2
1.5
1
0.5
0
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Core Inflation
Output gap (right axis)

Goals

- Present **model** that accounts for these patterns
  - Developed to study productivity growth during the GR
  - Accounts for productivity growth before GR, and recent recovery
  - Also accounts for evolution of inflation
- Key **mechanism**: Cyclical response of technology adoption
- Provide **evidence** on the mechanism
- A **historical account** of productivity dynamics and inflation

Model

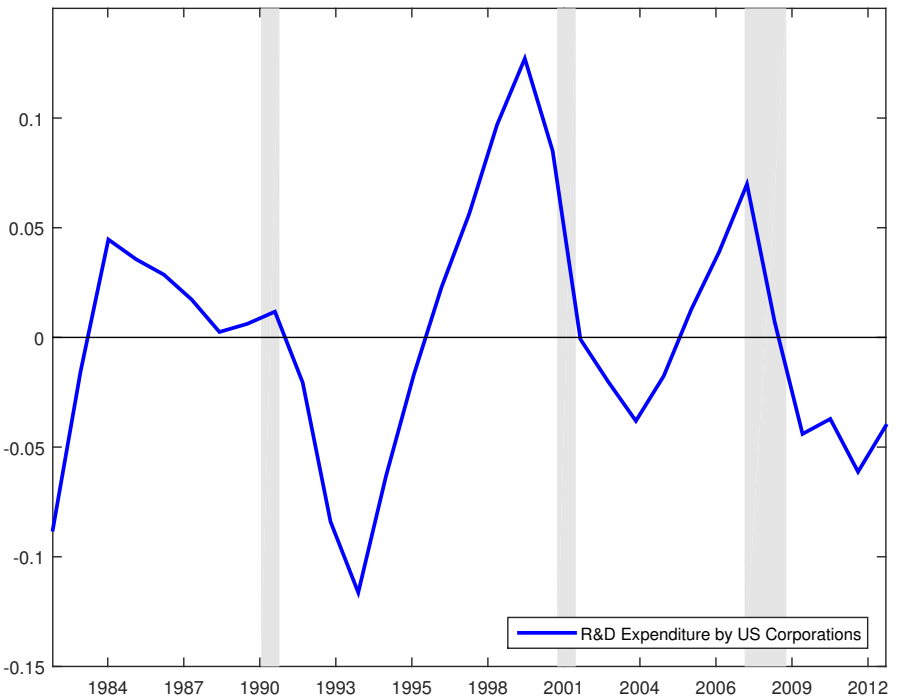
1. $y_t = y_t^p + y_t^s$
2. $y_t^s = \bar{\alpha}_\chi \chi_t - \bar{\alpha}_R R_t$
3. $R_t = R_t^f + r_t^p$
4. $R_t^f = \bar{\alpha}_\pi \pi_t + \bar{\alpha}_y y_t^s$
5. $\Delta\pi_t = \bar{\kappa} mc_t + \varepsilon_t$
6. $mc_t = -\bar{\eta}_a a_t + \bar{\eta}_y y_t^s$
7. $\Delta y_t^p = \bar{\rho} \Delta a_t$
8. $\Delta a_t = \bar{\nu}_\lambda \lambda_{t-1} + \bar{\nu}(z_{t-1} - a_{t-1})$
9. $\lambda_t = \bar{\gamma}_y y_t^s - \bar{\gamma}_R R_t$
10. $\Delta z_{t+1} = \chi_t + \bar{\theta} s_t$


Output
Consumption
Investment
Inflation
Nominal R
Spread $R^k - R$
Endogenous TFP
R&D
Adoption Rate
% Dev. from S.S.
% Dev, Annual
%, Annual
%, Quarterly
Baseline Model
Exogenous TFP

Evidence

Cyclicality of Adoption

Figure 2: R&D Expenditures by US Corporations, 1983-2013



Log-linearly detrended data. Source: R&D Expenditure by US corporations (National Science Foundation). Data are deflated by the GDP deflator and divided by the civilian population older than 16 (see Appendix A.1 for data sources).

Cyclical Adoption: A Shred of Evidence

- Survey data: sample of 26 production technologies that diffused at various times over the period 1947-2003 in the US (5) and the UK (21).

- $m_{it} \equiv$ fraction of potential adopters that have adopted technology i at time t
  - $\longrightarrow$ ratio of adopters to non-adopters $r_{it} = m_{it}/(1 - m_{it})$
  - $\longrightarrow$ speed of diffusion $Speed_{it} = \triangle \ln(r_{it})$

- Econometric specification

$$Speed_{it} = \alpha_i + \eta_1 lag_{it} + \eta_2 (lag_{it})^2 + \beta * \widehat{y}_t + \epsilon_{it},$$

lag_{it} time from introduction of technology i

$\widehat{y}_t \equiv$detrended output

Table 1: Cyclicality of the Speed of Technology Diffusion

	I	II	III	IV
$\widehat{y}_t$	3.73	3.7	3.64	4.12
	(3.59)	(2.81)	(3.94)	(3.17)
$\widehat{y}_t$ * US		0.07		-0.74
		(0.04)		(0.53)
lag_{it}	-0.057	-0.057		
	(5.22)	(4.76)		
lag_{it}^2	0.001	0.001		
	(2.52)	(2.12)		
$ln(lag_{it})$			-0.29	-0.29
			(6.68)	(6.65)
R2 (within)	0.11	0.11	0.13	0.13
N technologies	26	26	26	26
N observations	327	327	327	327

Notes: (1) dependent variable is the speed of diffusion of 26 technologies, (2) all regressions include technology specific fixed effects. (3) t-statistics in parenthesis, (4) $\widehat{y}_t$ denotes the cycle of GDP per capita in the country and represents the high and medium term components of output fluctuations, (5)$\widehat{y}_t$*US is the medium term cycle of GDP per capita times a US dummy, (6) lag represents the years since the technology first started to diffuse.

Figure 3: Speed of Diffusion

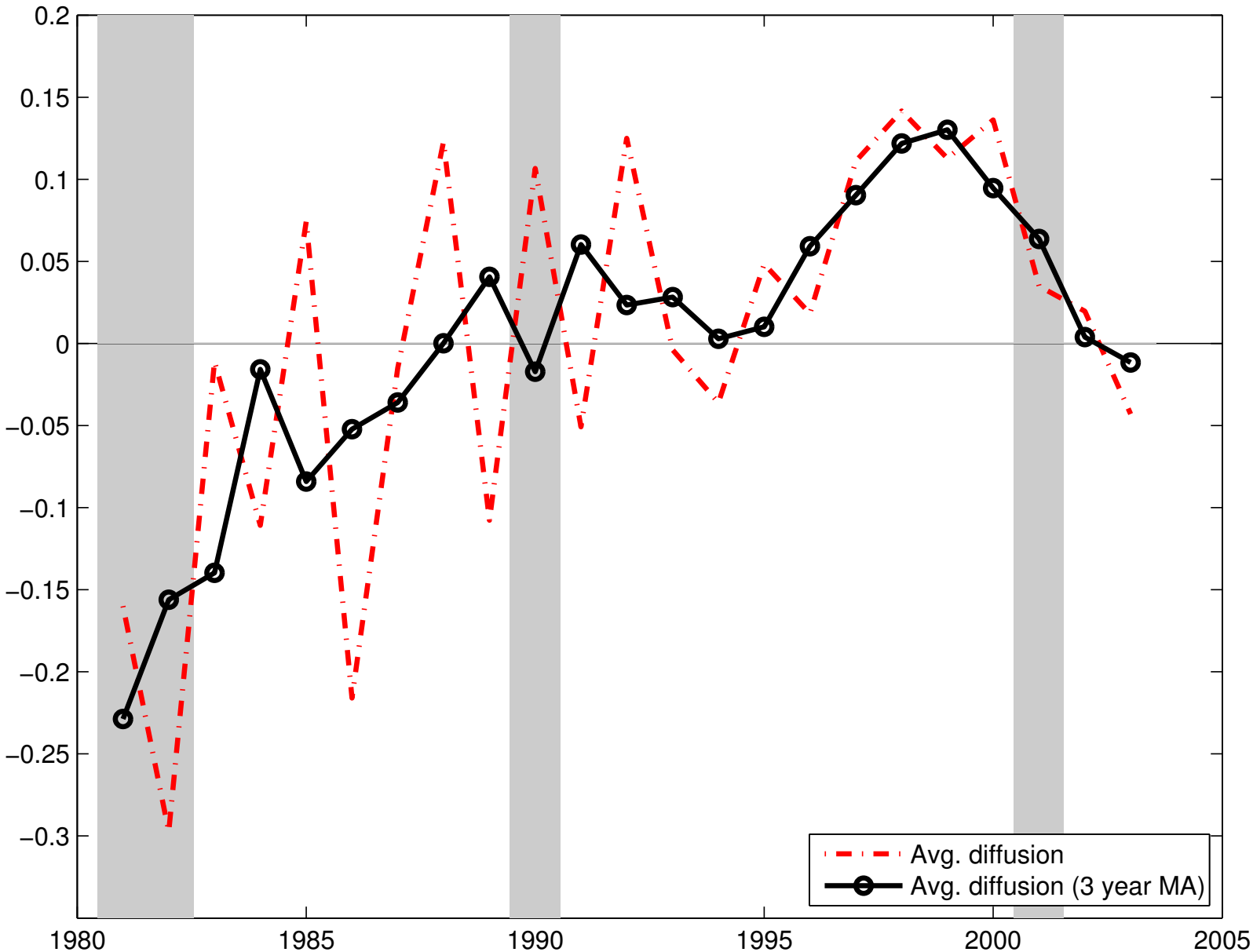
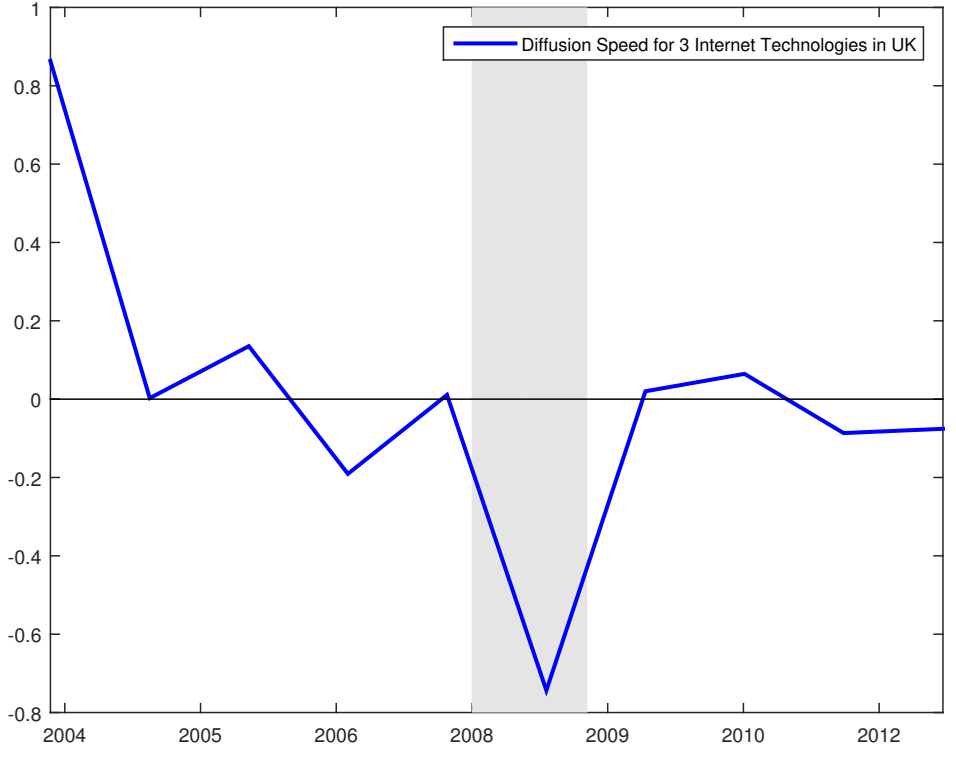
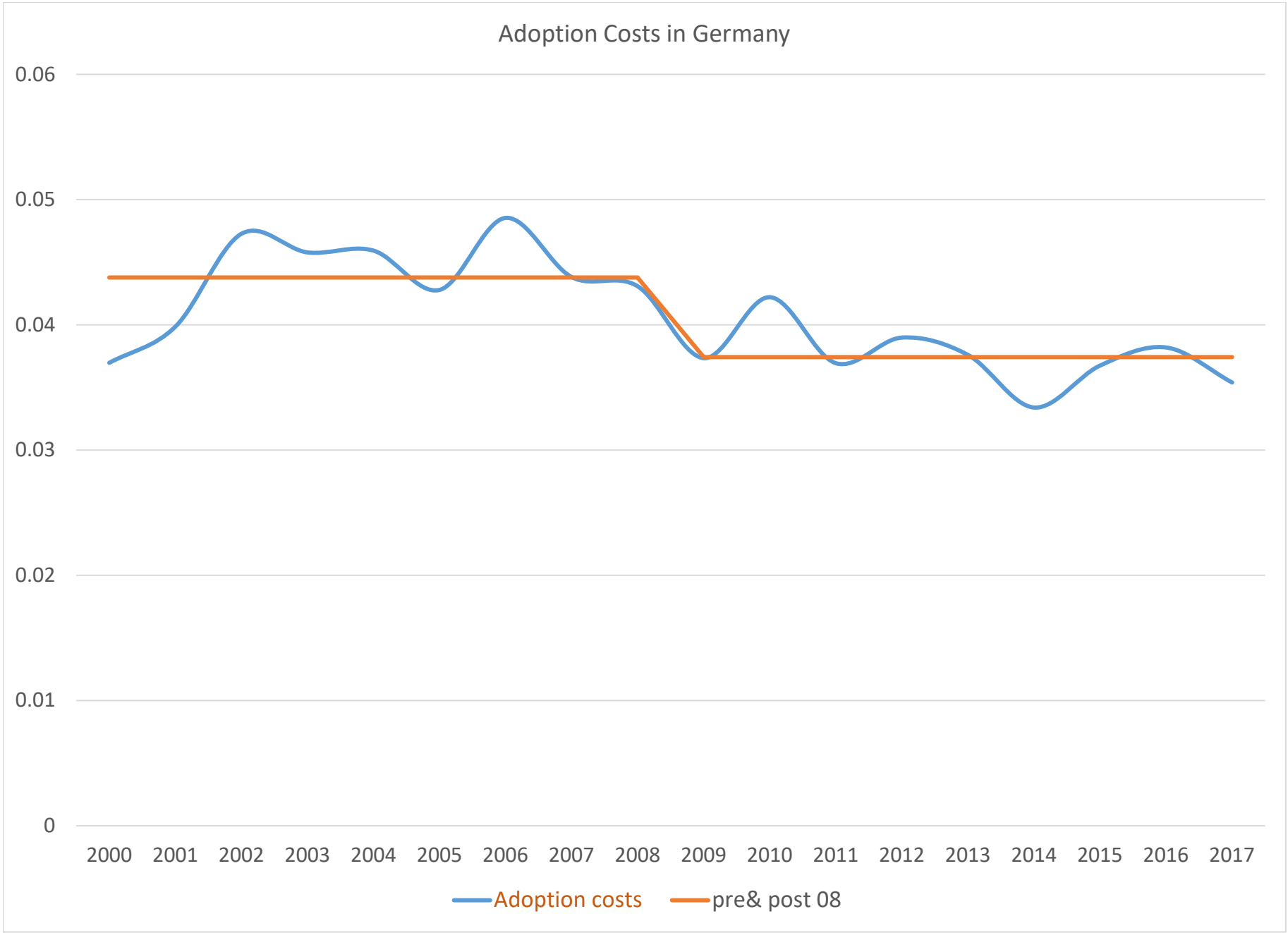
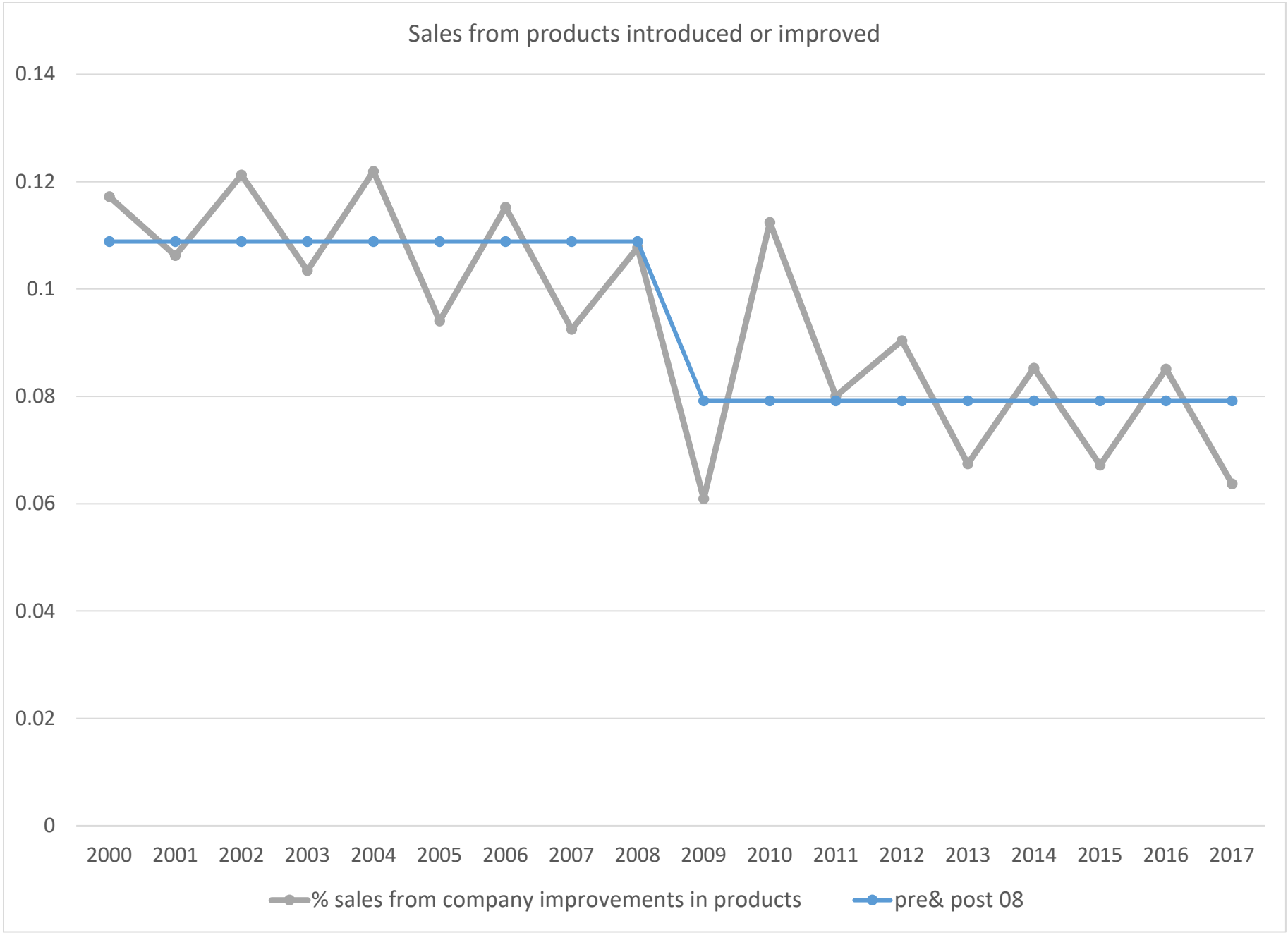


Figure 4: Diffusion Speed for 3 Internet Technologies in the UK, 2004-2013



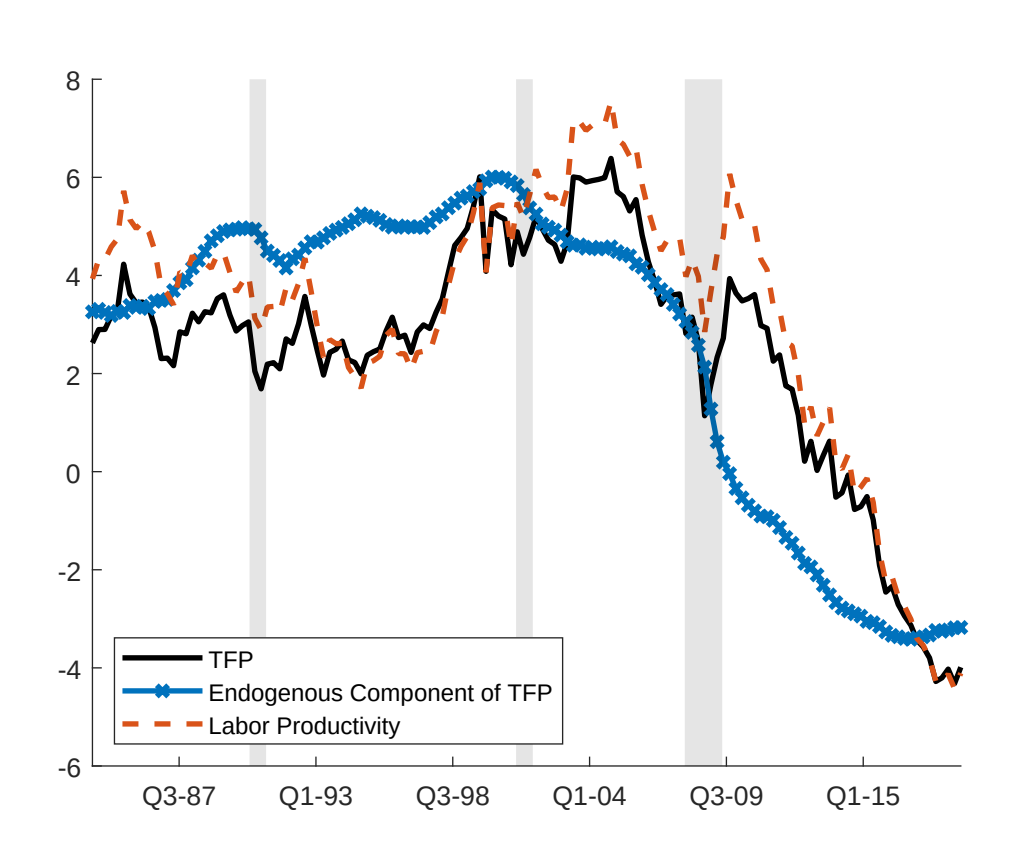
Source: Eurostat; see footnote 6 for details of calculations. Shaded areas are UK recession dates as dated by UK ONS.

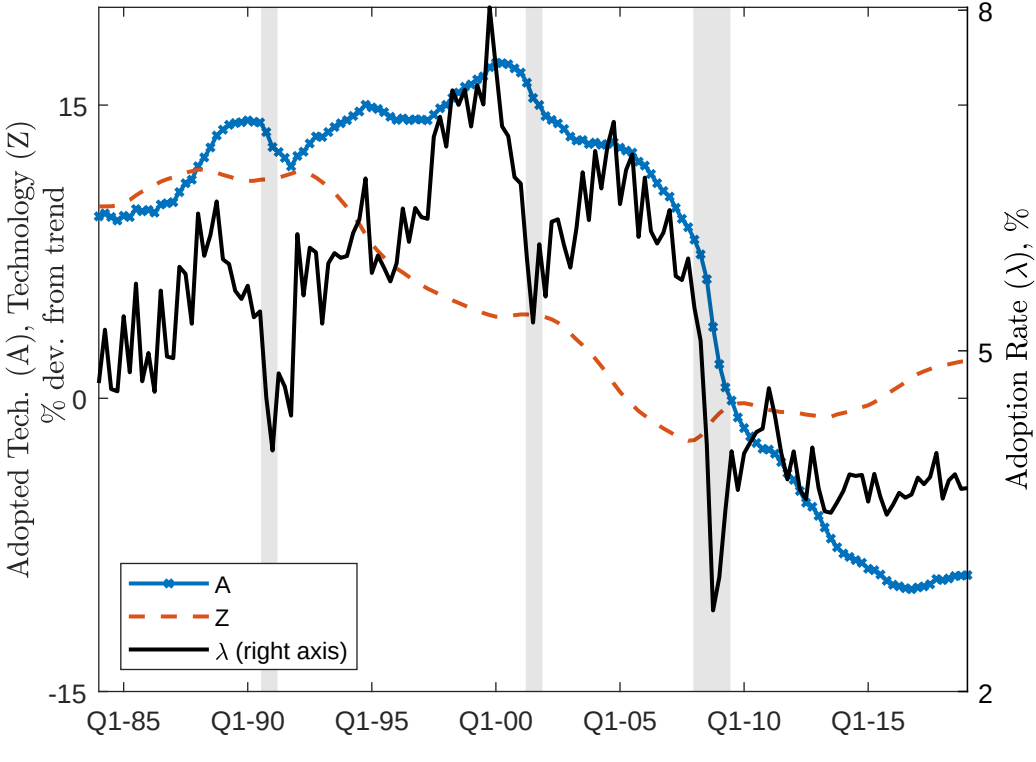

Adoption Costs in Germany
0.06
0.05
0.04
0.03
0.02
0.01
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Adoption costs
pre& post 08


Sales from products introduced or improved
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
% sales from company improvements in products
pre& post 08


% Reduction production costs
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Unit cost reductions
pre& post 08

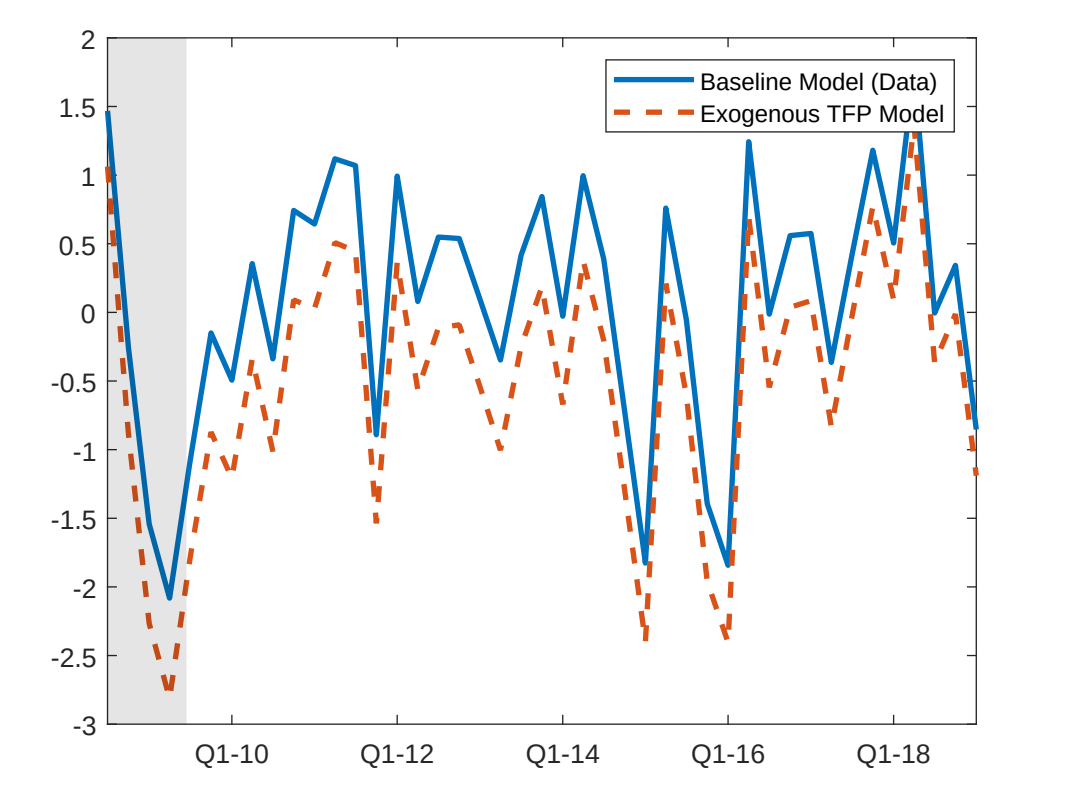
Historical Account

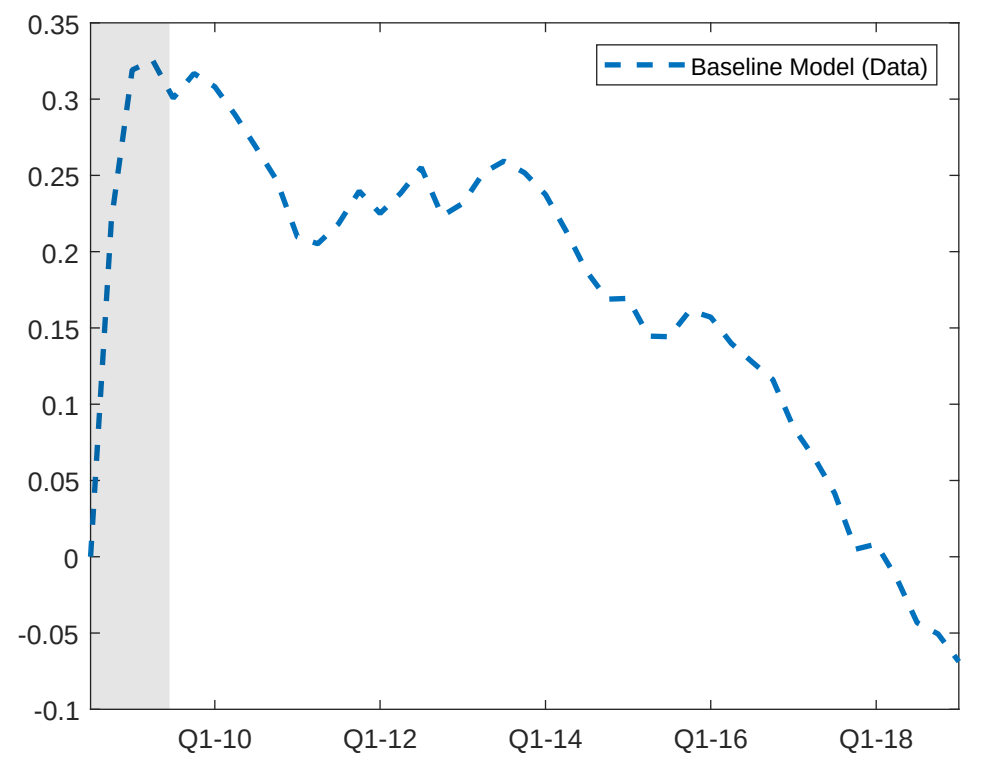

8
6
4
2
0
-2
-4
-6
Q3-87
Q1-93
Q3-98
Q1-04
Q3-09
Q1-15
TFP
Endogenous Component of TFP
Labor Productivity


Adopted Tech. (A), Technology (Z)
% dev. from trend
Adoption Rate (λ), %
15
0
-15
8
5
2
Q1-85
Q1-90
Q1-95
Q1-00
Q1-05
Q1-10
Q1-15
A
Z
λ (right axis)

Take Away TFP

- Slowdown in TFP largely due to endogenous component
- During GR and post-GR: liquidity demand slows down adoption rate
- Prior to GR: R&D productivity declines in 2001, and this leads to lower TFP growth from 2005-2008
- In recent times: adoption rate stabilized, and TFP grows at pre-GR rate due to catch up
- Heterogeneity in adoption between leaders and followers could explain TFP divergence


Baseline Model (Data)
Exogenous TFP Model
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Q1-10
Q1-12
Q1-14
Q1-16
Q1-18


Baseline Model (Data)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
Q1-10
Q1-12
Q1-14
Q1-16
Q1-18

Take Away inflation

- Higher than expected inflation during and after GR, due to lower level of endogenous TFP
- (Due to TFP convergence) this effect has disappeared and now endogenous TFP leads to lower than expected inflation