Online Appendix for *Beyond Pangloss: Financial sector origins of inefficient economic booms* (F. Malherbe and M. McMahon)

I Model Extensions

In this Appendix, we outline two extensions to the baseline model to show that the main findings carry over, with some interesting new results, to more elaborate environments.

I.1 Liquidity provision, bank runs, and regulatory response

In the models developed in the main text, we abstracted from important dimensions of banking and took as given the existence of the guarantees (except in the MM economy, of course). In this extension, we give two additional economic role to banks (next to credit provision to firms): they now also provide liquidity and diversification services to households. The problem is that they are then exposed to the risk of runs, which we show is a rationale for the existence of government guarantees. Still, absent government guarantees, banks would use financial trading to provide insurance to patient depositors. However, with guarantees, they instead choose to use it to extract rents and a Beyond Pangloss equilibrium occurs.

I.1.1 Augmenting the model

In the tradition of Diamond and Dybvig (1983), we now consider households that have a preference for liquidity: household j has utility function.

$$E[u\left((1-\beta_j)c_{\text{aft}}+\beta_j c_{\text{eve}}\right)],$$

where $u(.)$ is as before but $\beta_j \in \{0,1\}$, with $\Pr(\beta_j = 0) = j$, represents an idiosyncratic liquidity shock, which *iid* realisation is private information to the household and, c_{aft} denotes afternoon consumption, and c_{eve} evening consumption.

Financial and labour market activity takes place in the morning. Then, production starts and the households learn their type: *aft* ($\beta_1 = 0$) or *eve* ($\beta_1 = 1$). A first, safe payoff ak^α arises to firms in the early afternoon (with $a \leq A^L$). It is used to pay wages. The remainder can be repaid to the bank and, in turn, be used to repay early depositors. The risky part of the payoff ($(A-a)k^\alpha$) arises in the evening, and goes to the bank.[26]

Here, households cannot directly trade with the rest of the world: they can only hold deposits or bank equity. Banks, on the other hand, can trade the Arrow securities described in the main text. However, international financial markets can only settle at night. We normalise the risk-free rate to 0.

Definition. In a *first best allocation*, production is set at the efficient level, where the expected marginal productivity of capital is 1 (this corresponds to the MM allocation in the main text), and there is perfect insurance. That is, irrespective of their type agents consume the same (as long as $aK_M^\alpha \geq je$, there is enough resource to provide for afternoon households; we assume this is the case). Hence, the full expected economic surplus from production is equally split among households. They therefore consume:

$$e + (E[A]K_{\text{MM}}^\alpha - K_{\text{MM}}) = e + (1-\alpha)E[A]K_{\text{MM}}^\alpha = e + w_{\text{MM}}$$

I.1.2 Sketch of the analysis and discussion

Without guarantees, the following decentralised arrangement can implement the first best. Household deposit their endowment with the bank against a promise that they can withdraw it one for one, either in the afternoon or in the evening. The bank lends to firms, up to K_{MM}, and hedges production risk with the rest of the world (any excess deposit is lent at the zero risk free rate). As a result, total resources available to the bank through the day is simply e.

[26]For simplicity we abstract here from contractual considerations between the firm and the bank.

Bank runs Now, consider a coordination failure, where *all* depositors run the bank in the afternoon. The bank cannot repay them all and is forced into bankruptcy. In that case, we assume the proceeds from the second payoff are not collected in full. Hence, evening depositors that anticipate a run are indeed better off running, and a run can be self-fulfilling.

Deposit insurance As usual, deposit insurance (with ex-post lump-sum taxes on evening households) prevents the coordination failure (Diamond and Dybvig, 1983). However, we now face an environment that is essentially identical to that leading to the Beyond Pangloss equilibrium. Now that depositors are insured, the bank has no incentive to use financial markets to hedge production risk away. To the contrary, it will use financial trades to shift the risk onto the taxpayer as we described in section 3.

Exploitability of guarantees and ban on financial trades As in our general model capital requirements can help (i.e. the distortion is decreasing in γ), but the more exploitable the guarantees are (i.e. the larger ϕ) the more overinvestment is exacerbated. However, here, banning financial trades (which corresponds to $\phi = 0$) is no panacea. This is because in this extension financial trades are potentially useful since they allow bank to hedge domestic risk and provide full insurance to households. In particular, the first best allocation is not attainable if $\phi = 0$.

Stress-tests Note that, in the Beyond Pangloss model, the losses in the bad state correspond to 100% of the amount lent. So, from that point of view, a 100% capital requirement is needed. In practice, however, since the assets are posted as bankruptcy remote collateral, it can also make sense to apply capital requirements to the financial portfolio directly. This is regardless of there being liquidity risk or not. The only way for capital requirements to prevent risk-shifting is to make sure that the bank cannot default, even in the worst possible scenario. This resonates with the stress-tests exercises that have been imposed on banks since the global financial crisis.

I.2 Asset price inflation

We introduce here a second type of capital. The production function in the economy is still the Cobb-Douglas function given by (1), but the stock of capital itself is given by the following constant elasticity of substitution aggregator:

$$K = \left(Q^{\xi} + S^{\xi}\right)^{\frac{1}{\xi}},$$

where $\xi \in (0,1)$ is the elasticity of substitution between Q and S. Q denotes equipment and S stands for structures (and land). For simplicity, equipment is imported, at an exogenous unit price $p_e > 0$, and structures are in perfectly-inelastic supply, with $S = 1$.[27] The firm buys structures from households at the beginning of the period at an endogenous competitive price p_s.

Because we want to be able to account for possible secular trends in the economy, we parametrise capital depreciation. In particular, we assume that, at the end of the period, equipment and structures can be converted into consumption goods at rates $p_e(1-\delta)$ and $p_s(1-\delta)$, respectively, with $\delta \in (0,1]$. Finally, rather than the proceeds from lending, here we assume it is the capital itself that is collateralised. But we restrict this to structures allowing the bank to pledge up to a share $\phi \in [0,1]$ of the structures to outside investors (equipment is not collateralisable).

Equilibrium with government guarantees As in the Beyond Pangloss economy, the representative bank will maximise rent extraction, which gives (stars indicate equilibrium values):

$$h^* = \phi \frac{1-q}{q}(1-\delta)S^*.$$

Accordingly, the lending problem of the representative bank can formalised, with a slight abuse of notation (we are directly using aggregate variables for the representative bank, which still takes factor prices as given), as:

$$\max_{N,Q,S} q\left(A^H N^{1-\alpha}\left(Q^{\xi} + S^{\xi}\right)^{\frac{\alpha}{\xi}} - Nw - q_e(\delta + r)Q - q_s(\delta + r)S + \phi\frac{1-q}{q}(1-\delta)S\right).$$

[27] An alternative would be to have structures built with a combination of land, labour, and equipment. This would complicate the analysis without adding much further insight.

From the first order conditions for Q and S, we get:

$$Q^* = S^* \left(\frac{p_s(\delta + r) - \phi \frac{1-q}{q}(1-\delta)}{p_e(\delta + r)} \right)^{\frac{1}{1-\xi}}. \tag{22}$$

Substituting for Q in the first order conditions for N and S, and using $N = S = 1$ yields:

$$\begin{cases} (1-\alpha)\, A^H \left(\left(\frac{q_s(\delta+r) - \phi \frac{1-p}{p}(1-\delta)}{q_e(\delta+r)} \right)^{\frac{\xi}{1-\xi}} + 1 \right)^{\frac{\alpha}{\xi}} = w \\ \alpha A^H \left(\left(\frac{p_s(\delta+r) - \phi \frac{1-q}{q}(1-\delta)}{p_e(\delta+r)} \right)^{\frac{\xi}{1-\xi}} + 1 \right)^{\frac{\alpha}{\xi}} = p_s(\delta + r) - \phi \frac{1-q}{q}(1-\delta) \end{cases}, \tag{23}$$

which is a system of two equations in p_s and w that pins down the equilibrium.

Results This system can be solved numerically. It is easy to check that to obtain the equilibrium conditions of the corresponding MM economy of the extended model, one must substitute $E[A]$ for A^H and set ϕ to 0 in System 23 and Equation 22 above.

Compared to the MM economy, in this extended model, the economy with guarantees exhibits a series of symptoms similar as those in the Beyond Pangloss economy: (i) higher GDP and lower expected NDP; (ii) inflated wage; (iii) over investment in capital (materialising through an increase in Q^*); and (iv) a higher capital to output ratio. However, it also features new distortions:

Inflated asset prices In particular, q_s^*, the price of structures, is increasing in A^H and ϕ. Figure A.1 shows that the relative price of investment, which has, in aggregate, been on a well-documented secular downward trend since the 1970s actually increased slightly before the financial crisis (black dashed line). While equipment goods prices continued to decline (yellow line), the prices of residential and particularly non-residential structure prices grew strongly for many years before the crisis (green and purple lines). These trends are consistent with the predictions of our extended model.

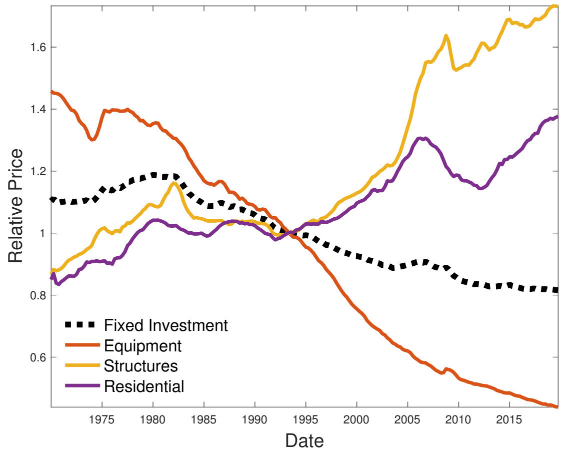


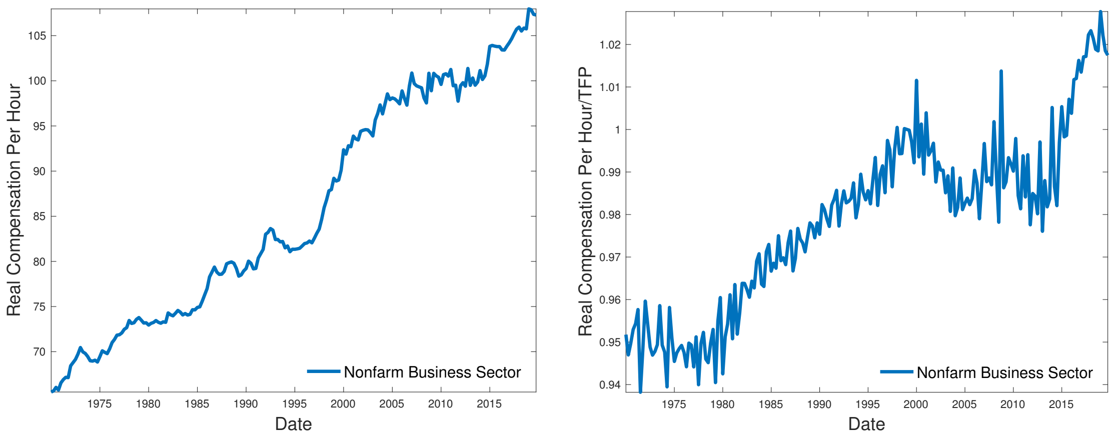
Figure A.1: Relative Price of Capital Investment (Index, 1994=100)
Notes: This figure shows Bureau of Economic Analysis (BEA) data on the investment good deflators as a ratio to the GDP deflator series. The evolution of the index describes the behaviour of the *relative* price of that type of investment good.

Ambiguous changes in the share of fixed asset income in GDP In particular, $\sigma^* \equiv \frac{Q^* p_e}{S^* p_s}$ is increasing in A^H, but decreasing in ϕ. That is, total gross income of all factors benefit from the increase in GDP, but, for instance, if the latter effect dominates, the increase is greater for fixed assets (structures), then labour, then equipment. This prediction speaks to the literature on the medium to long term trends for production factor shares of income (see e.g. Karabarbounis and Neiman 2013 and Piketty 2014), but fully studying such ramifications is beyond the scope of this paper.

II Real wage developments

The Panglossian model predicts that the period in advance of the crash would also have been marked by significant real wage growth. However, the Beyond Pangloss equilibrium generates a more nuanced prediction. The increase in investment boosts wages but banks' concern about the collateral value in the low state restrains competition for workers and tends to decrease the wage. The net effect is ambiguous.

Figure A.2a shows the index of real compensation per hour in the non-farm business sector. This begins to accelerate from around 1998 until the financial crisis. Between 2009 and 2014, real wages were virtually stagnant.[28] However, relative to TFP (Figure A.2b), measured using Fernald's utilisation-adjusted TFP measure, real wages have a much more mixed performance; they grew in late 1990s but then largely stagnated over the next 15 years.



(a) Real Wages per Hour

(b) Real Wages per hour relative to TFP

Figure A.2: Real Wages

Notes: This figure shows the index of non-farm business sector real compensation per hour. The index is set to 100 in 2009. Figure (a) shows the raw index while figure (b) shows the index relative to utilisation-adjusted TFP.

[28]Clymo (2017) provides evidence that real wages were gradually adjusted down in the US (as well as in the UK) after the crash.

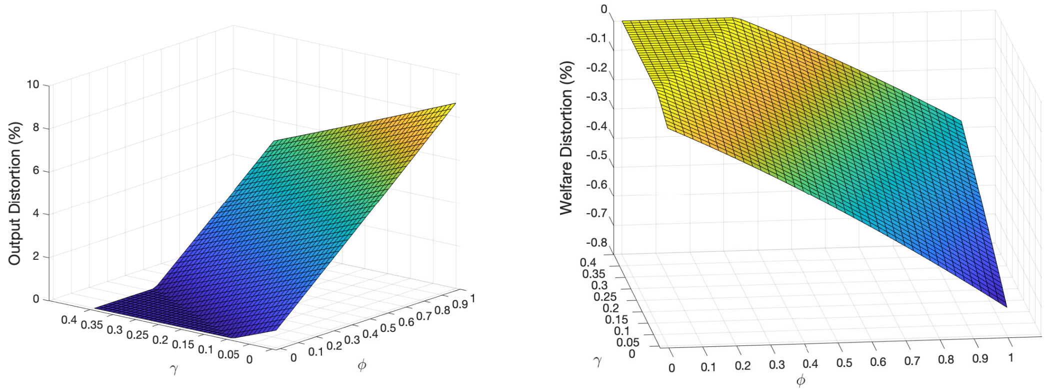
III Calibration of the General Model

In the main text we explore a number of calibrations of the general model to highlight the implications of pledgeability for the distortion of output and reduction of welfare. In this section, Figure A.3 plots the model results for a whole range of values for ϕ and γ. This exercise uses the same calibration parameters as presented in the main text and reported in Table 1.

Concept	Parameter	Values
Pledgeability	ϕ	$[0, 1]$
Capital Regulation	γ	$[0, 0.4]$
Persistence of H State	q	0.95
Capital Share	α	0.38
High State Productivity	A^H	1.0
Low State Productivity	A^L	0.9
Real Interest Rate	r	0.02

Table 1: Calibration for Quantitative Exploration of the Model
Notes: This table shows the calibration values used in the quantitative evaluation of the distortions in the general model.

Figure A.3 reinforces the two messages in the main text. First, the distortion in the Panglossian equilibrium is modest ($\phi = \gamma = 0$) and regulation can easily neutralise it as per Krugman (1999); holding fixed $\phi = 0$, the effect of tightening capital regulation is to quickly return the outcome of the MM economy (no distortion). Second, high pledgeability quickly overcomes the effects of regulation; when $\phi = 0.175$, stringent regulation (for example, $\gamma = 0.25$ as used in the main text) is no longer enough to neutralise the distortion which grows with the degree of pledgeability.



(a) Effect of ϕ and γ on output distortions

(b) Effect of ϕ and γ on welfare

Figure A.3: Effect of Pledgeability (ϕ) and capital regulation (γ)

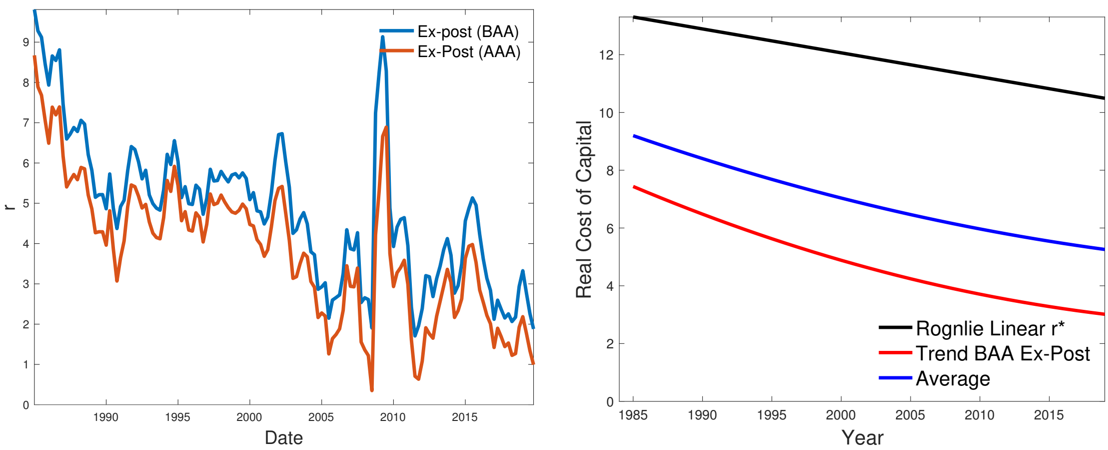
Notes: This figure repeats the simulation of the general model in section 4.1 as used in Figure 2 but for a wider range of parameters.

IV Data Description: Confounding factors for the residual calculation

In section 6 in the main text, we construct a Solow-inspired, back-of-the-envelope estimate of the size of the distortion. Here we provide a more-complete description of the data used for confounding factors for equation (10).

Real cost of capital The main component of the user cost of capital in (10) is the cost of finance. There is a large literature that suggests there has been a secular decline in interest rates over the last 25 years (for example Summers (2014)). There are many series that could be used to capture the real user cost.

One candidate series to measure the cost of finance is a bond yield series. These series, at least with a long enough time-series, are nominal and therefore need to be adjusted for inflation expectations to be comparable to the model driving variable. For simplicity, we use a measure of ex-post real interest rate. Figure shows the ex-post AAA and BAA bond yields since 1985; using ex-post measures between 1972 and 1985 is problematic as inflation was highly variable making ex-post measures extremely volatile. The ex-post bond yields show a clear secular decline over the period.



(a) Ex-post real bond yields (b) Trends in real costs of funds

Figure A.4: Secular trends in real costs of funds: ex-post real bond yields

Notes: This figure shows the trends for the real cost of funds provided in by ex-pot bond yield measures and the estimates from Rognlie (2015). The red line shows the weighted average that we use to control for declining real interest rates.

Of course, bond yields miss the cost of equity which is typically a lot higher. Rognlie (2015) backs out an implied measure of the real cost of funds from financial markets by comparing the difference between firms' market value and the value of their fixed assets which captures the discounted value of expected future pure profits which can then be used to infer an implied r. This approach helps to overcome the difficulty, caused by the fact that reliance on debt versus equity finance differ across firms, of backing the real cost of funds out of bond and equity prices. However, the Rognlie calculation yields a very high value of the real return (the estimates are in the range 12-15%[29]).

Rognlie estimates the trends over the period 1947 to 2013 (in Figure 7 of Rognlie, 2015); we update the linear trend to get estimates of the annual cost of finance to 2019. As with the ex-post real yields, the Rognlie measure has declined. Figure A.4b shows the adjusted trend values for r from 1985 to 2019, as well as the BAA ex-post measure and its trend. While the trends in both series are similar, we choose to use a baseline estimate of the overall real cost of finance that is a weighted combination of the two series. Specifically, the blue line in Figure A.4b is $r_t = \psi . r_t^{BAA} + (1 - \psi) . r_t^{Rognlie}$ where $\psi = 0.7$.

In the model, r is exogenous. One concern may be that the distortion causes it to change endogenously. However, the direction of the endogenous reaction is not clear cut. One channel of the effect would be that, because households' future tax liabilities increase on average, saving may increase meaning that in a closed economy r would decline. A second channel comes from increased investment demand which would cause r to increase. Unclear on how to adjust for this effect, we proceed without further adjustment of the cost of funds.

Depreciation Higher average depreciation increases the user cost of capital which will, ceteris paribus, reduce the capital-output ratio. Using BEA data on nominal capital consumption $(\delta_t K_t)$, which uses fixed depreciation rates for each capital type multiplied by the composition of capital accounted for by that type of capital, we derive an estimate of average depreciation in each period.[30] Given that computers depreciate more quickly than other assets, it is often assumed that the average rate of depreciation rose in the last quarter of a century. In principle, this makes it important to control for δ_t (as increases in δ lower the capital to output ratio, which would cause us to understate the distortion). However, as we show in Figure A.5, after having sharply increased in the 1970s,

[29] This is driven by the fact that in the US Financial Accounts the market value is below the book value for much of the sample and firms are assumed to make no pure profits on average. In his discussion of Rognlie's paper, Robert Solow questioned whether level was biased and so was too high saying: "It is hard to believe that the discount rate was this high from 1950 to 2010. (Household saving was available at an interest cost of 4 to 5 percent; one would have expected more investment to have taken place.)" (Solow, 2015).

[30] There is no equivalent BLS measure of depreciation.

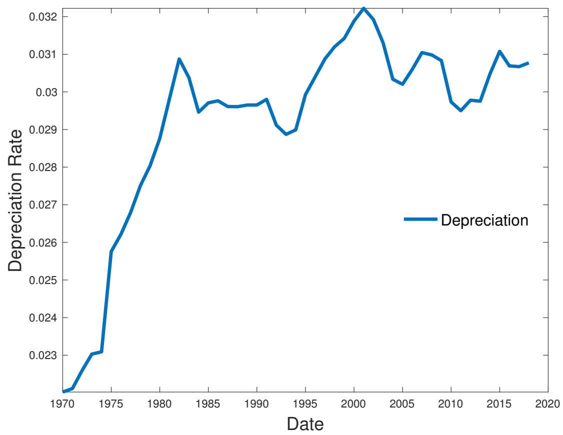


Figure A.5: Depreciation Rate Implied by BEA Capital Consumption
Notes: This figure shows the implied nominal depreciation rate obtained by dividing nominal consumption of fixed capital by the capital stock using BEA data. The shaded area represents our base years of 1993-1995.

depreciation does not really show a trend since the 1980s.

TFP In the absence of distortions in the model, decisions about capital investment are based on expectations of productivity. Realised productivity that is above (below) the expected level bias down (up) the capital-output ratio as it means that the pre-determined level of capital stock generates more (less) output than was expected; this drives the denominator up (down).

In order to adjust for this, we can use capacity-utilisation-adjusted TFP estimates provided by Fernald (2012). To measure the expected value, we use a 4th-order polynomial trend estimated over the entire sample from 1947 to 2019. Figure A.6 shows our estimates of both the level of TFP and our estimate of the trend. In the calculation, we use the deviations of TFP from this trend.

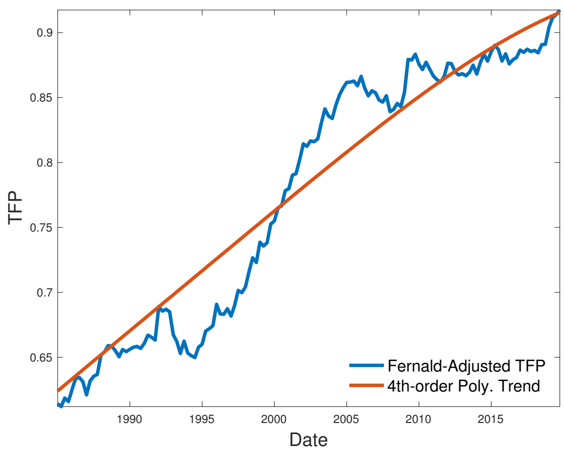


Figure A.6: Fernald's Capacity-Utilization Adjusted TFP and Trend
Notes: This figure shows the time series of Fernald's capacity-utilisation adjusted TFP index. It is plotted alongside 4th-Degree Polynomial trend.

V Robustness of BPD_t Estimates

In the main text, we present a number of different estimates of the KYR_t residuals under alternative assumptions concerning the treatment of the confounding variables. We also discussed a number of different ways to calculate KYR_t^* in order to estimate the Beyond-Pangloss Distortion (BPD$_t$); trend B– D measures all seemed at least somewhat reasonable. Finally, we can estimate KYR_t separately for each of the of the measures of the capital to output ratio (BLS and BEA), and also take the average KYR_t between the estimates. For robustness, we explore every possible combination of these choices.

In Figure A.7, we plot the range (dotted lines) as well as the baseline Trend C and D measures reported in the main text.

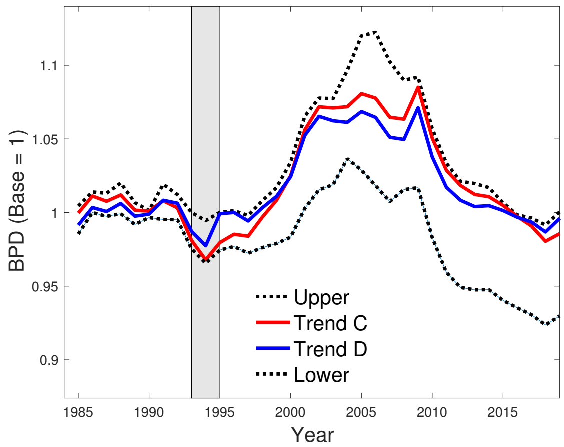


Figure A.7: BPD_t Range

Notes: These figures display the range of alternative estimates of the BPD_t series using different capital stock measures, different assumptions on the confounding factors and different assumptions about how to detrend KYR_t.