Sensitivity analysis of capital and MFP measurement to asset depreciation patterns and initial capital stocks

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Outline of the presentation

1. Impact of changing depreciation rates on:
   - Net capital stocks
   - Capital services and MFP growth
   - GDP (through non-market CFC)
2. Impact of initial capital stock estimates on:
   - Net capital stocks
   - Capital services and MFP growth
3. Conclusion

1. DEPRECIATION RATES

Assessing the influence of depreciation rates: Why and how?

- From one country to another, statistical agencies use very different assumptions to measure asset depreciation and retirement.
- These assumptions are often based on thin empirical evidence or old research.
- Unexplained differences may harm the cross-country comparability of macroeconomic indicators:
  - Capital stocks, capital services and MFP
  - All macroeconomic indicators measured net of depreciation (e.g. net investment rates)
  - GDP (via non-market CFC and output)

Assessing the influence of depreciation rates: Why and how?

- **Comparing asset retirement and depreciation patterns across countries:**
  - Combined depreciation/retirement profiles (i.e. *cohort* depreciation profiles) are convex and approximately geometric (Hulten and Wykoff, 1981)
  - Even for countries using non-geometric profiles, geometric approximations to their combined depreciation/retirement profiles can be estimated

- **We use the US as a laboratory for our experiment:**
  - We use the GFCF series broken down by asset and industry released by the BEA
  - We plug the geometric cohort depreciation rates of other countries into the US PIM: official geometric cohort depreciation rates for Canada, geometric approximations for France, Germany, Italy and the UK.

Cross-country differences in cohort depreciation rates

- **Canada, France, Germany and the UK**: geometric (approximations of) cohort depreciation rates are higher than in the US, in particular for Dwellings, Buildings other than dwellings, and Other structures
- **Italy**: closer to the US

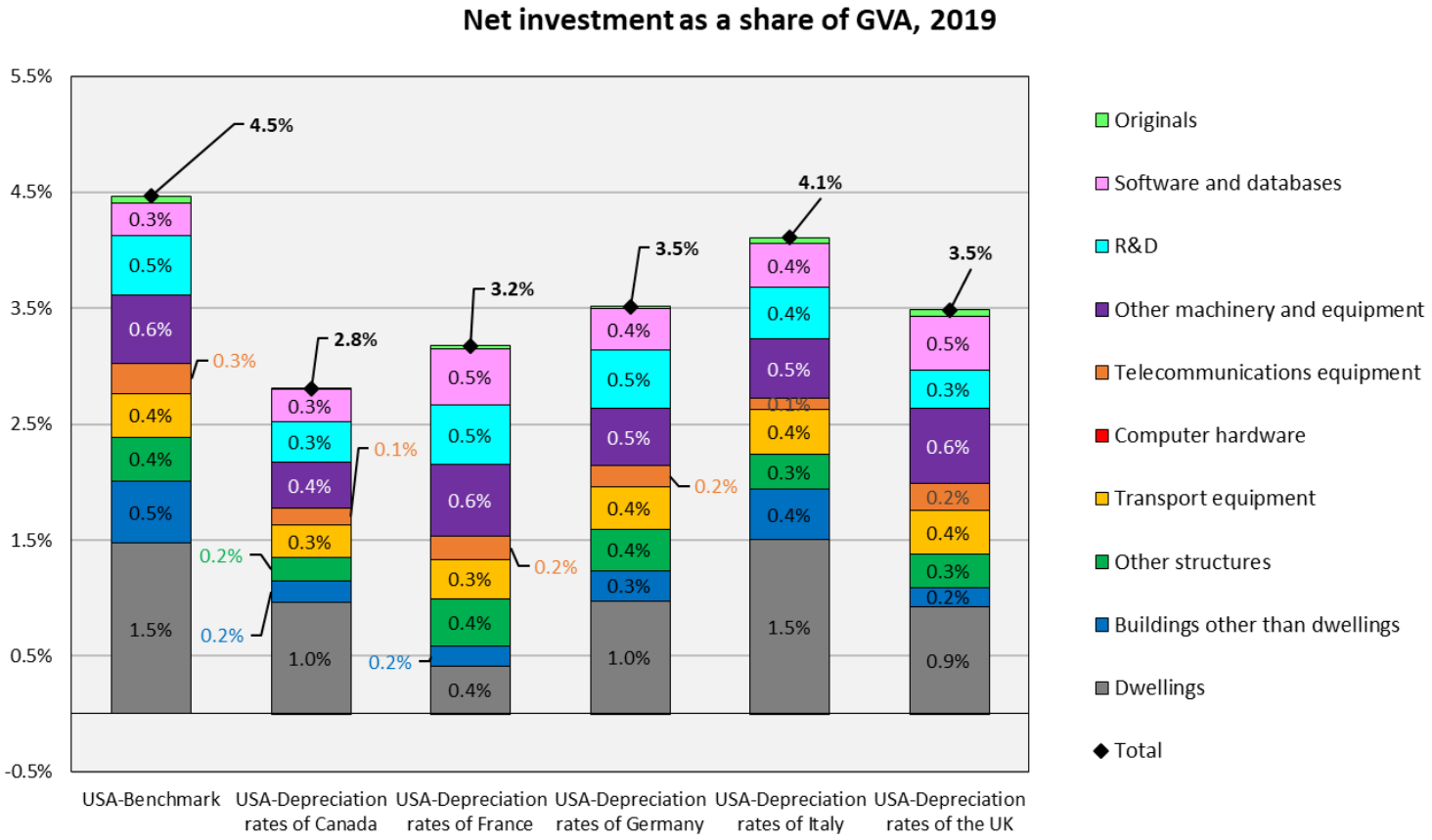
Ratios of cohort depreciation rates in Canada, France, Germany, Italy and the UK, relative to the US

Asset label	Canada	France	Germany	Italy	United Kingdom
Dwellings	2.0	5.0	2.4	1.6	2.5
Buildings other than dwellings	3.0	2.8	2.1	1.4	3.1
Other structures	2.7	1.1	1.4	1.6	1.7
Transport equipment	1.5	1.5	1.4	1.1	1.3
Computer hardware	1.3	1.2	0.8	1.4	1.2
Telecom. equipment	2.1	1.4	1.6	2.8	1.2
Other mach. & equipment	1.8	1.1	1.5	1.4	1.1
R&D	1.8	1.0	1.0	1.3	1.8
Software & databases	1.0	0.7	0.9	0.9	0.7
Originals	6.3	2.6	2.7	1.4	1.5

Note: Ratios higher than 1.5 are highlighted in orange, and ratios higher than 2.0 are highlighted in red.
These ratios are first calculated for detailed assets, and then aggregated to the upper level of the asset classification using capital stock shares as weights

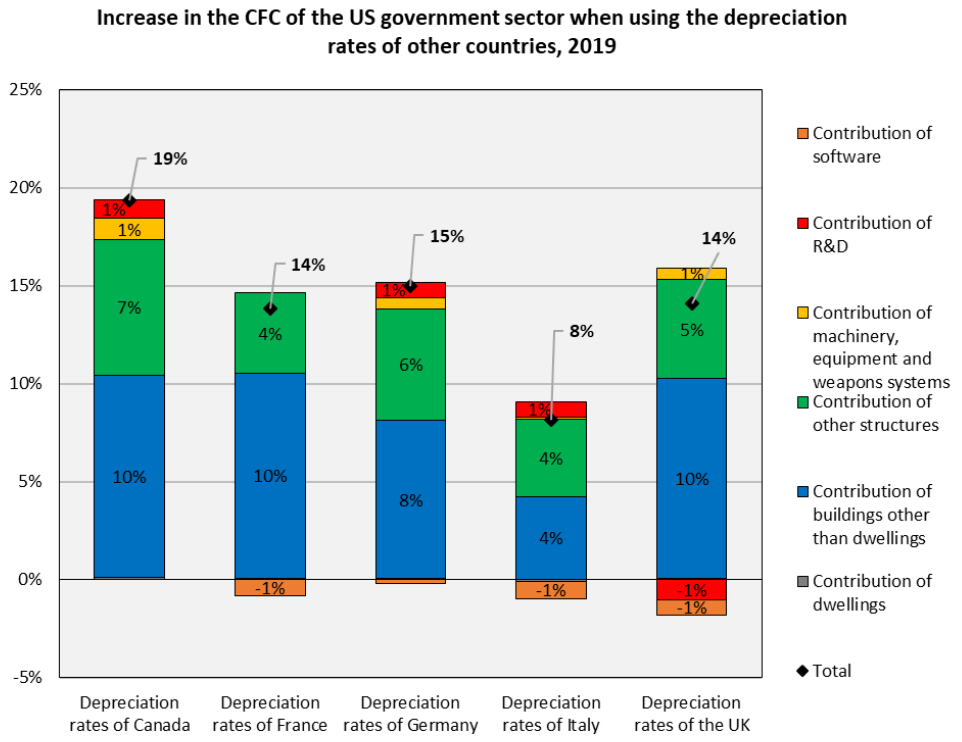
Impact on net investment rate (US private sector)

- Applying the same depreciation rates as in other G7 countries would reduce the net investment rate of the US private sector by up to 1/3.



Impact on GDP (via non-market CFC and output)

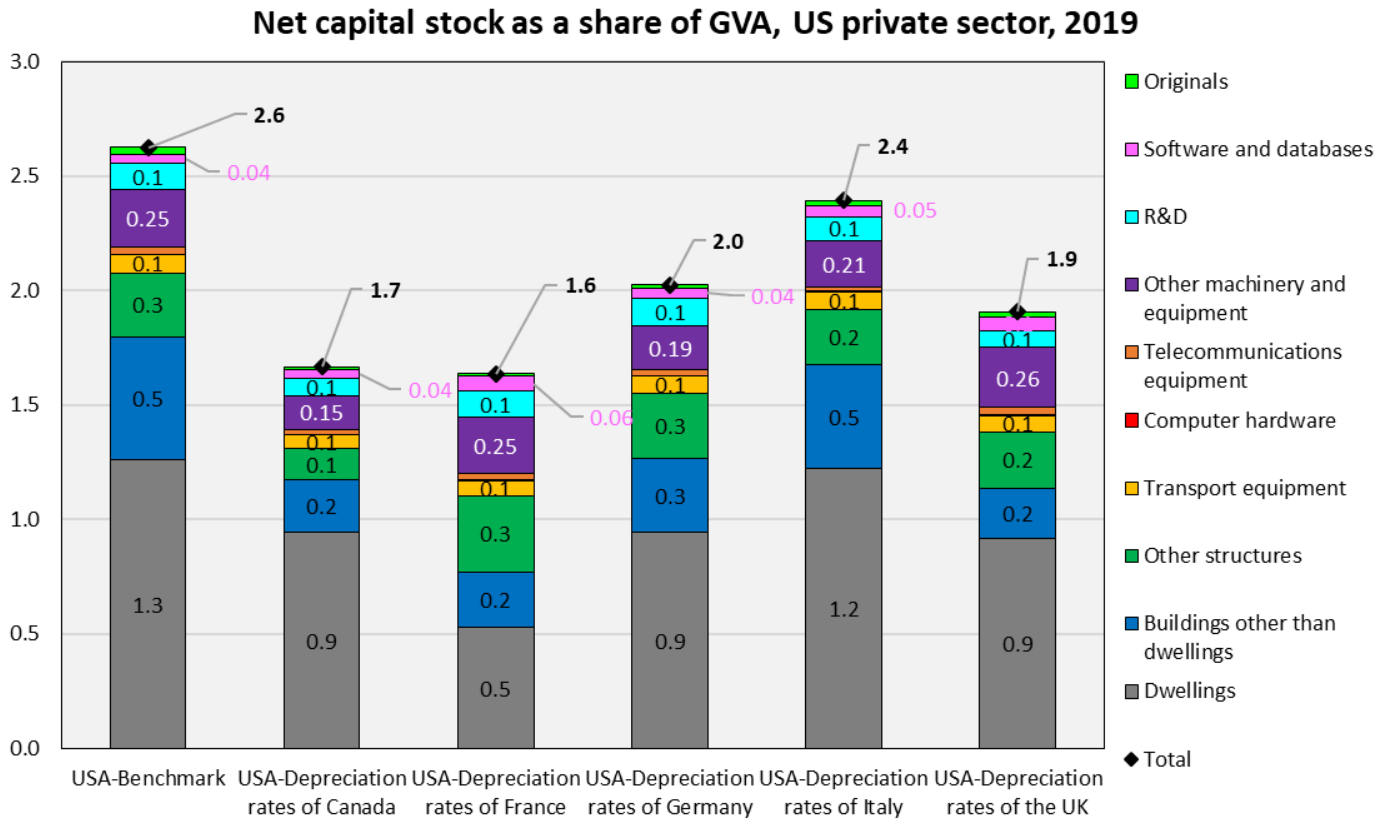
- The CFC of the US government sector would be revised by up to +19%.
- Nominal US GDP would be revised by up to +0.5%.



	Alternative depreciation rates				
	CAN	FRA	GER	ITA	GBR
Impact on US GDP (2019)	+0.5%	+0.4%	+0.4%	+0.2%	+0.4%

Impact on net capital stock (US private sector)

- The level of the US private sector net capital stock would be reduced by up to 1/3.
- More limited impact on the growth rate of the net capital stock (at constant prices) than on its level (at current prices).



Impact on capital services and MFP growth (US private sector)

- Capital services growth over 1997-2019 would remain largely unchanged.
- Largest impact during the Great Recession period (2006-2012)

	USA - Benchmark	USA – Depreciation rates of Canada	USA – Depreciation rates of France	USA – Depreciation rates of Germany	USA – Depreciation rates of Italy	USA – Depreciation rates of the UK
1997-2019	**2.9%**	**2.7%**	**2.8%**	**2.9%**	**3.0%**	**2.9%**
1997-2006	3.7%	3.6%	4.0%	3.9%	3.8%	3.8%
2006-2012	1.8%	1.5%	1.2%	1.6%	1.8%	1.5%
2012-2019	2.7%	2.8%	2.7%	2.8%	2.8%	2.8%

- MFP growth would be largely unaffected.

	USA - Benchmark	USA – Depreciation rates of Canada	USA – Depreciation rates of France	USA – Depreciation rates of Germany	USA – Depreciation rates of Italy	USA – Depreciation rates of the UK
1998-2019	**0.6%**	**0.7%**	**0.7%**	**0.6%**	**0.6%**	**0.6%**
1998-2006	0.7%	0.8%	0.6%	0.7%	0.7%	0.7%
2006-2012	1.5%	1.7%	1.8%	1.6%	1.6%	1.7%
2012-2019	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%

2. INITIAL CAPITAL STOCKS

Assessing the influence of initial capital stocks: Why and how?

- In addition to asset depreciation/retirement profiles and GFCF, **the PIM requires initial capital stocks to initiate the estimation process**.
- **The shorter the available GFCF series, the larger the influence of the initial capital stocks** on future capital stocks, especially for long-lived assets.
- While the US releases GFCF series starting in 1901, many (Central and Eastern) European countries only release GFCF series starting in the mid-1990s.

Assessing the influence of initial capital stocks: Why and how?

Two main approaches to estimate initial capital stocks:

1. Stationarity assumption on investment growth rates

For each asset, investment is assumed to grow at a constant rate. This rate is estimated over the period where GFCF is available.

$$K_{i,t} = \sum_{j=0}^{N} (1-\delta_i)^j I_{i,t-j} = \sum_{j=0}^{N} \left(\frac{1-\delta_i}{1+\theta_i}\right)^j I_{i,t} \quad \Rightarrow \quad \boldsymbol{K_{i,t} = \frac{1+\theta_i}{\theta_i+\delta_i} I_{i,t}} \text{ provided that } \left|\frac{1-\delta_i}{1+\theta_i}\right| < 1$$

2. Stationarity assumption on K/Y

K/Y is assumed to be constant over time (Solow growth model). Based on external information on K/Y (e.g. cross-country average), GDP at date t is used to estimate K_t .

→ Method used to estimate initial capital stocks in the Penn World Tables (PWT)

Assessing the influence of initial capital stocks: Why and how?

- We assume that US GFCF series are shorter than in reality (1950, 1980 or 1995 instead of 1901) and estimate initial capital stocks based on the two previous approaches. All other PIM parameters are left unchanged.
  - Stationarity assumption on investment growth: average growth rates estimated over the first 20 years where GFCF is available
  - Stationarity assumption on K/Y: same method as PWT8.0 (2013)

Asset category	Capital stock-to-output ratio (total economy)
Structures (residential and non-residential)	2.2
Transport equipment	0.1
Other machinery and equipment	0.3
All other assets (i.e. IT equipment, Software, and Originals)	0

Source: Inklaar and Timmer (2013)

Impact on net capital stocks: Overview

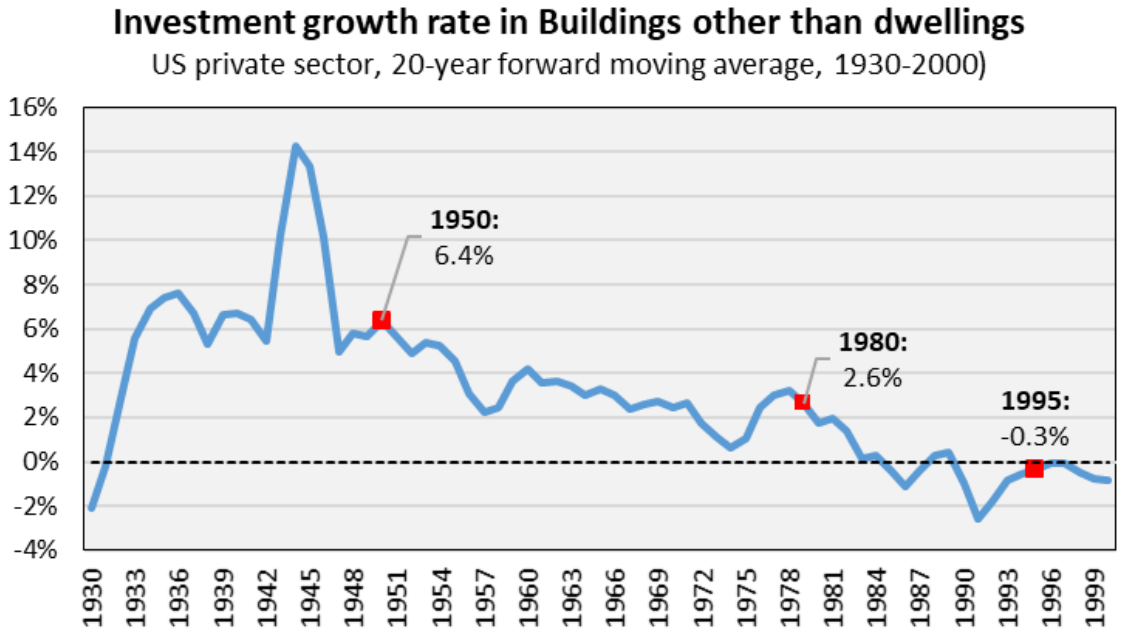
			Stationarity assumptions on investment growth rates		Stationarity assumptions on K stock-to-output ratios	
Starting date of investment series (D)	Asset	Share of initial K stock remaining in 2005 (%)	Ratio between estimated and BEA K stocks at initial date (D)	Ratio between estimated and BEA K stocks in 2005	Ratio between estimated and BEA K stocks at initial date (D)	Ratio between estimated and BEA K stocks in 2005
1950	**Total**		**1.8**	**1.0**	**1.0**	**1.0**
1980	**Total**		**1.3**	**1.0**	**0.9**	**0.9**
1995	All structures	76.4	**26.1**	**15.8**	1.2	1.0
	Transport equipment	24.6	1.2	1.0	1.5	1.0
	Other machinery and equipment	28.2	1.1	1.0	1.0	1.0
	IT, Software and Originals	15.2	1.2	1.1	0.0	0.9
	Total		**20.5**	**13.0**	**1.1**	**1.0**

Impact on net capital stocks: Stationarity assumptions on investment growth

- **Stationarity assumptions on investment growth can be very misleading, especially for structures**

  → with GFCF series starting in 1995, the capital stock of structures in 2005 is 16 times higher than BEA estimates

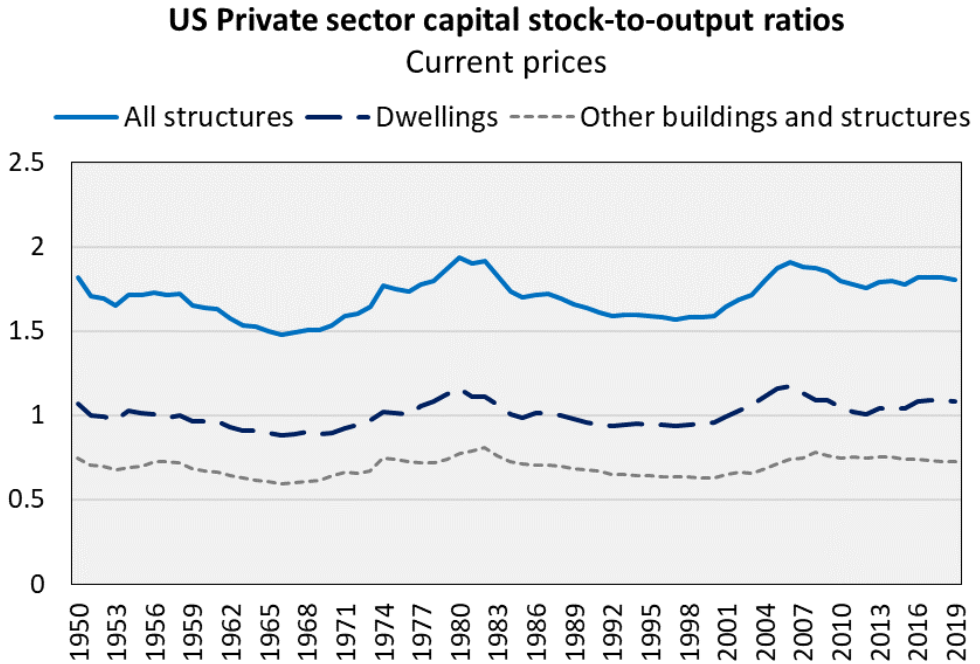
- **Explanation**: large fluctuations and long-term trend in the growth rate of GFCF for structures → investment growth is not constant over time



Impact on net capital stocks: Stationarity assumptions on K/Y ratios

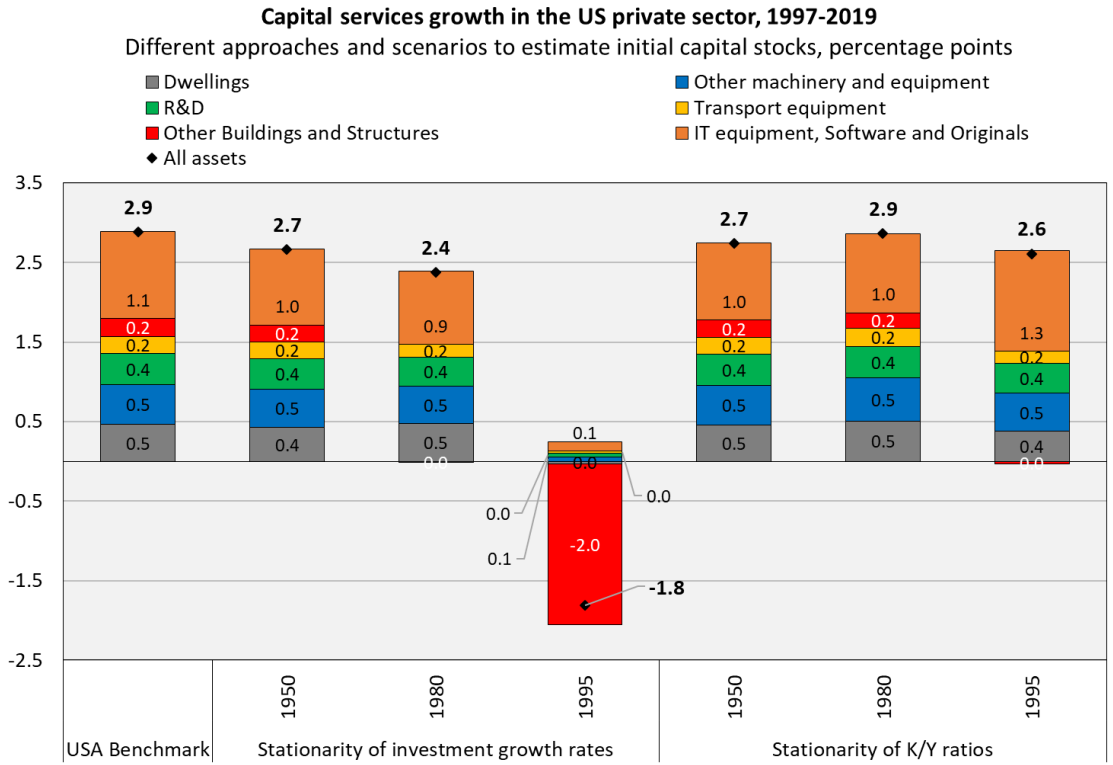
- **Better results with stationarity assumptions on K/Y**: always in the +10/-10% range around BEA estimates for all main assets, in all scenarios (1950, 1980 and 1995)
- **Explanation**: K/Y ratios are more stable than investment growth rates

- **Caveat**: Large dispersion in K/Y across countries. Results for other countries may be less reliable than for the US.
- **Recommendation for countries**: Invest time and resources to extend GFCF series to the maximum extent, based on historical national accounts and external sources



Impact on capital services and MFP growth

- Stationarity asumptions on GFCF growth rates may significantly affect capital services and MFP growth, especially if GFCF time series are short.
- Better results with stationarity asumptions on K/Y and longer GFCF time series



3. CONCLUSION

Conclusion (1)

- The depreciation rates used by the US BEA are (much) lower than those used in Canada, France, Germany and the UK, in particular for buildings and structures. They are closer to those used in Italy.
- Using the depreciation rates of other G7 countries would reduce the net capital stock and the net investment rate of the US private sector by up to 1/3.
- Capital services and MFP growth would be much less affected.
- When estimating initial capital stocks, stationarity assumptions on investment growth can be very inaccurate, especially for long-lived assets and with short GFCF series.

Conclusion (2)

- Stationarity assumptions on K/Y work better for the US, but this result may not apply to all countries.
- Recommendations for countries:
  - Review asset depreciation and retirement patterns regularly
  - Use stationary assumptions to estimate initial capital stocks carefully
  - Before relying on any stationarity assumption, extend GFCF series as much as possible, based on historical vintages of national accounts, administrative sources, and company accounts.

Thank you

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