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Investment as a transmission mechanism from weak demand to weak supply and the post-crisis productivity slowdown

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ABSTRACT/RÉSUME

Investment as a transmission mechanism from weak demand to weak supply and the post-crisis productivity slowdown

Current weak labour productivity growth in many OECD countries reflects historically weak contributions from both total factor productivity (TFP) growth and capital deepening. The slowdown in trend productivity growth in the pre-crisis period is mostly explained by a long-established slowdown in TFP growth, but since the crisis the further deceleration is mainly due to weak capital deepening, a development apparent in practically every OECD country. Much of the weakness in the growth of the capital stock since the financial crisis can be explained by an accelerator response of investment to continued demand weakness, leading in turn to a deterioration of potential output via a hysteresis-like effect. For the most severely affected economies, the financial crisis is estimated to have reduced potential output by more than 2% via this transmission mechanism. In many OECD countries, declining government investment as a share of GDP has further exacerbated post-crisis weakness in capital stock growth, both directly and probably indirectly via adverse spillover effects on business investment. Finally, over a period when the use of conventional macro policy instruments was constrained, the slower pace of structural reform represents a missed opportunity, not least because more competition-friendly product market regulation could have boosted both investment and potential growth.

JEL Classification: E22; E27; E32; E65; E66

Keywords: financial crisis, global financial crisis, potential output, capital stock, investment, capacity, accelerator effect, hysteresis

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L'investissement comme mécanisme de transmission entre demande faible et offre faible et ralentissement de la productivité après la crise

La faiblesse actuelle de la croissance de la productivité du travail dans beaucoup de pays de l'OCDE reflète des contributions historiquement faibles à la fois de la productivité totale des facteurs (PTF) et de l'intensité capitalistique. Le ralentissement de la croissance tendancielle de la productivité sur la période précédant la crise s'explique par un ralentissement de la croissance de la PTF sur longue période, mais depuis la crise, l'accentuation de la décélération est principalement due à la faiblesse de l'intensité capitalistique, et ce dans pratiquement tous les pays de l'OCDE. Le ralentissement de la croissance du stock de capital s'explique principalement par une réaction de type accélérateur de l'investissement à la faiblesse continue de la demande, ce qui alors a diminué le potentiel de production via un effet d'hystérèse. Pour les pays les plus sévèrement touchés, on estime que la crise financière aurait réduit le potentiel de production de plus de 2% via ce mécanisme de transmission. Dans beaucoup de pays de l'OCDE, la baisse de la part de l'investissement public dans le PIB a encore exacerbé le ralentissement de la croissance du stock de capital observé après la crise, à la fois directement et aussi indirectement via des retombées négatives sur l'investissement des entreprises. Enfin, pendant une période où l'utilisation de politiques macroéconomiques conventionnelles était contraintes, le rythme ralenti de réforme structurelle représente une occasion manquée, notamment parce que des réglementations plus favorables à la concurrence sur les marchés de produits auraient pu stimuler à la fois l'investissement et la croissance potentielle.

Classification JEL : E22 ; E27 ; E32 ; E65 ; E66

Mots clés : crise financière, crise financière globale, potentiel de production, stock de capital, investissement, capacité; effet accélérateur, hystérèse.

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INVESTMENT AS A TRANSMISSION MECHANISM FROM WEAK DEMAND TO WEAK SUPPLY AND THE POST-CRISIS PRODUCTIVITY SLOWDOWN

Patrice Ollivaud, Yvan Guillemette and David Turner[1]

1. Introduction and summary

1. Following the global financial crisis there has been a marked slowdown in productivity and potential growth across most OECD countries while investment has been unusually weak (OECD, 2016a; OECD, 2015a). This paper considers the links between these phenomena; both the contribution that weak investment has made to lower productivity and potential growth, as well as the extent to which weak investment has been propagated by the shock associated with the financial crisis. In doing so, it addresses a question which Janet Yellen recently highlighted as one of the most important macroeconomic research priorities after the crisis, namely "*are there circumstances in which changes in aggregate demand can have appreciable, persistent effects on supply*?" (Yellen, 2016). She went on to quote a study focussed on the United States that showed that following the financial crisis there was "*a marked slowdown in the estimated trend growth of labour productivity*" which was likely a reflection of "*an unusually slow pace of capital accumulation*" (Reifschneider et al., 2015). The current paper considers the same issue, but using the experience of all OECD countries rather than that of a single one.

2. The main findings of the paper are as follows:

- Recent weak trend labour productivity growth in many OECD countries reflects historically weak contributions from both total factor productivity (TFP) and capital per worker.
- For most OECD countries, the slowdown in trend productivity growth over the period 2000 to 2007 is mostly explained by a slowdown in TFP growth, but since the crisis, the further deceleration in trend productivity is mostly due to weak growth in capital per worker.
- Much of the recent weakness in the growth of the capital stock can be explained by an accelerator response of investment to the negative demand shock following the financial crisis. Those countries experiencing the most severe downturns have also suffered the most marked slowdown in capital stock growth. This suggests the operation of an important hysteresis-like effect over the post-crisis period, whereby continued weakness in demand has led to deterioration in potential output via weaker growth in the capital stock.

[1] The authors are economists and Head of Division, respectively, in the OECD Economics Department. They would like to thank Oliver Denk, Professor Don Heon Kim, Catherine L. Mann, Jean-Luc Schneider, Peter Hoeller, Balàzs Égert, Nadim Ahmad and Asa Johansson for comments on an earlier version of the paper, as well as Sylvie Toly and Alexandre Kopoin for statistical support and Veronica Humi for technical assistance. This paper represents an extension of work previously reported in Ollivaud (2016).

- Increasing evidence, including from firm-level studies, suggests that many countries where interest rates were particularly low in the pre-crisis period, especially in Southern Europe, experienced a substantial misallocation of capital in the pre-crisis period. These countries are also amongst those that experienced a more abrupt post-crisis adjustment in capital stock growth. This experience provides a cautionary note about the possible dangers of policy-makers deliberately running the economy "hot" in order to reverse supply-side damage to capital accumulation.
- To the extent that macro policy responses, especially from monetary policy, have cushioned the post-crisis downturn, they may have helped to limit the damage to potential growth, although empirical evidence of the beneficial effects of lower interest rates on investment is surprisingly meagre. On the other hand, government investment as a share of GDP since the crisis has fallen in many OECD countries and in aggregate across the OECD. This may not only have contributed to a direct reduction in the growth rate of the productive capital stock, but may also have had adverse indirect spillover effects on business investment: countries where government investment has been cut back most sharply are also those where growth of the whole-economy capital stock has slowed the most.
- Recent OECD empirical work suggests that structural reforms which promote competition in product markets boost capital intensity. However, while product market regulation has become more competition-friendly, the rate of improvement has declined in the post-crisis period. Thus, while the use of conventional macro policy instruments was constrained over much of the post-crisis period, the slower pace of structural reform represents a missed opportunity, not least because of the beneficial effects it would likely have had on investment and potential growth.

3. The analysis in the paper is based on estimates of potential output, trend productivity and its components rather than actual output and productivity to try to abstract from cyclical effects which are obviously severe following the crisis, although the uncertainties surrounding trend estimates add an important caveat to any conclusions reached.[2] The next section analyses the slowdown in trend labour productivity at the aggregate OECD level, whereas Section 3 applies the same analysis across individual countries to look for common patterns. A main finding is that weak growth in the capital stock has been the major explanation of post-crisis weakness in productivity growth, so section 4 considers alternative explanations for the weakness in investment. In Section 5, main conclusions from the paper are summarised. An appendix provides a decomposition of trend productivity growth for individual OECD countries into the contribution from total factor productivity and capital per worker.

2. The slowdown in aggregate OECD trend labour productivity growth

4. The current OECD method of estimating potential output assumes a Cobb-Douglas production function,[3] which can be simplified so that potential output (Y*) is expressed in terms of potential employment (N*), the capital stock (K) and labour-augmenting trend technical progress (E*), so that in logarithmic form:

[2] See Box 1.5 of OECD (2015b) and Turner et al. (2016) for a discussion of revisions to OECD measures of potential output.

[3] For further details see Appendix 3 of Turner et al. (2016).

$$y^* = \alpha (n^* + e^*) + (1 - \alpha) k, \quad [1]$$

where lower case letters denote logs and α is the wage share. Investment is defined as the change in the capital stock plus the depreciation of the previous period's capital stock, given a scrapping rate δ. Total factor productivity growth (TFP) is a simple transformation of labour efficiency, so that in logs: $tfp = \alpha e^*$.

5. The measure of the capital stock used to define potential output is the non-housing whole-economy capital stock in line with the current OECD methodology for estimating potential output.[4, 5] A rationale for using the actual capital stock, rather than a trend measure, is that it represents installed capacity which in principle could be utilised without generating inflationary pressure. A more practical reason for using the actual capital stock is the difficulty of identifying its trend component, particularly in the aftermath of the financial crisis. The sensitivity of the analysis to this choice is discussed further below.

6. An expression for trend labour productivity growth can then be derived in terms of a contribution from labour efficiency (or equivalently a contribution from TFP) and a contribution from changes in capital per worker, by subtracting potential employment from both sides of [1]:

$$\Delta(y^* - n^*) = \alpha \Delta e^* + (1 - \alpha) \Delta(k - n^*). \quad [2]$$

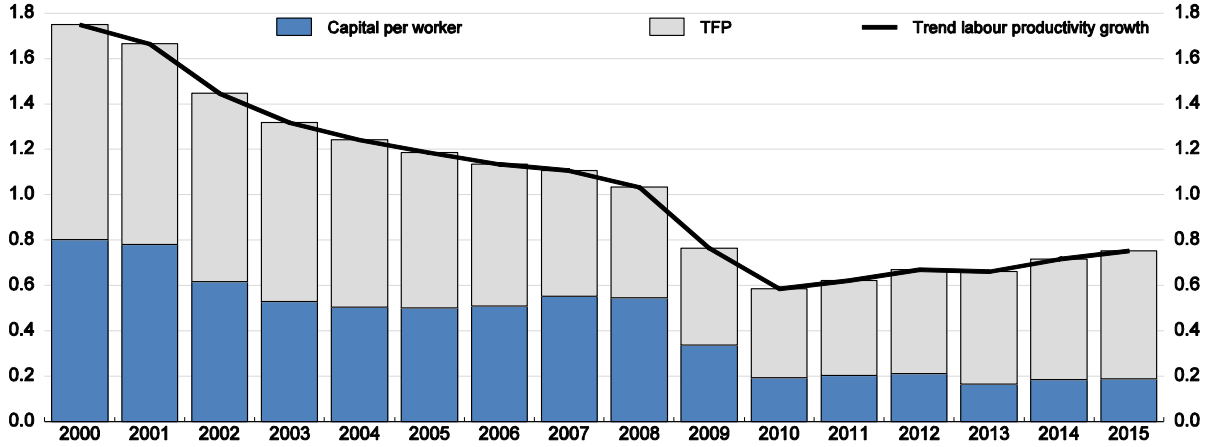
7. Aggregate OECD trend labour productivity growth declined from over 1¾ per cent per annum in 2000 to around 1% per annum just prior to the crisis (Figure 1). In the immediate aftermath of the crisis trend labour productivity slumped further, but has since recovered to about ¾ per cent per annum. The widespread slowdown in productivity growth is the most important reason of the slowdown in the growth rate of GDP per capita (a proxy for living standards), although other factors, such as ageing populations, have also contributed (see Box 1.3 of OECD, 2015c).

8. The decline in trend labour productivity growth can be split into contributions from total factor productivity (TFP) and capital per worker (Figure 1), on the basis of the decomposition described in [2] and an assumption about α which is taken to be 2/3. The slowdown in trend labour productivity growth in the pre-crisis period is mostly explained by a long-established slowdown in trend TFP growth. OECD trend TFP growth gradually slowed from 2000 to 2007, and dipped further following the crisis, but has since recovered to about pre-crisis (2007) growth rates. Conversely, the contribution from capital deepening slowed during the crisis and has remained subdued due to the prolonged weakness in investment. The slowdown in the contribution from growth in capital deepening of 0.4 percentage point per annum entirely explains the slowdown in trend productivity growth between 2007 and 2015.

[4] The capital stock data for 20 OECD countries, including all G7 countries, is taken from the OECD Statistics Directorate, but for other countries (Greece, Chile, Colombia, Czech Republic, Hungary Iceland, Israel, Latvia Mexico, Norway, Poland, Sweden, Slovak Republic, Slovenia and Turkey) it is generated from investment data using a perpetual inventory method.

[5] The measure of capital is also a measure of capital stock which is more appropriate for measuring potential output rather than a measure of capital services, which is more cyclical and better captures the contribution of capital to actual output.

Figure 1. Decomposition of the OECD-wide trend labour productivity growth rate



Note: The basis for the decomposition is summarised by equation [2] in the text.
Source: OECD Economic Outlook 99 database.

3. Country detail of the slowdown in trend labour productivity growth

9. The pattern of the decline in trend productivity and the contributions from TFP and capital per worker which are apparent for the aggregate OECD are also present, to differing degrees, in the overwhelming majority of OECD countries. Trend labour productivity growth slowed in most OECD countries between 2000 and the start of the crisis, and it has slowed further since the crisis (see Table 1 and Figure A1 in the Appendix for individual country details). Looking across all OECD countries, a striking pattern is that slowing trend labour productivity growth over the period 2000 to 2007 was mainly due to slowing TFP growth, but since the crisis the further slowdown is mostly explained by weaker growth in capital per worker (Figure 2, panels A and B):

- Between 2000 and 2007, trend labour productivity growth slowed in all but four of the 34 OECD countries. For three-quarters of OECD countries, weakening TFP growth accounts for most of this slowdown rather than capital deepening. In virtually all OECD countries, TFP growth slowed over this period and, for more than half of them, the contribution from TFP declined by more than ½ percentage point per annum (see Figure 2, panel B and the highlighted cells in column C4 of Table 1). Conversely, the contribution from capital per worker increased between 2000 and 2007 in as many countries as it declined (see Figure 2, panel A and column B4 of Table 1).

10. Despite similar patterns across many OECD countries, some have been more severely affected than others:

- The slowdown in capital per worker was greatest among those countries most severely affected by the crisis. In Estonia, Greece, Iceland, Portugal, Slovenia and Turkey, slowing growth in capital per worker dragged down post-crisis trend productivity growth by more than 1 percentage point per annum between 2007 and 2015.
- Slower TFP growth contributed more than 1 percentage point per annum to slowing trend labour productivity growth between 2000 and 2015 in the Czech

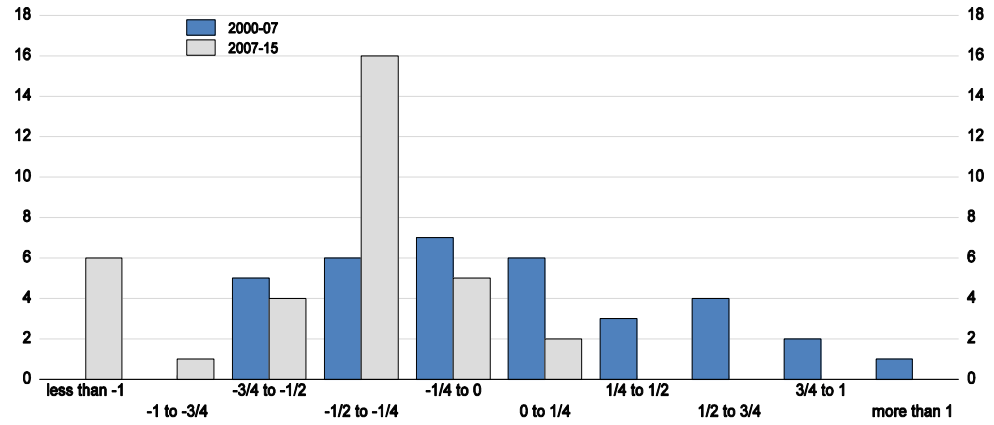
Republic, Finland, Greece, Hungary, Ireland, Poland, the Slovak Republic and Sweden.

11. Recent contributions of both TFP and capital per worker to trend labour productivity growth appear historically weak in many OECD countries:

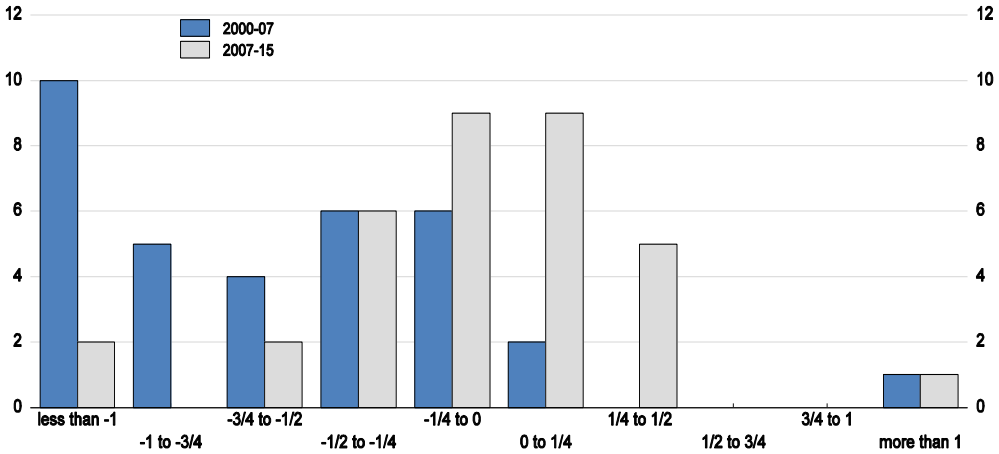
- While TFP growth has recovered since 2007 in many countries, recent performance remains weak: its contribution to trend labour productivity growth is estimated to be less than ½ percentage point in 2015 in two-thirds of OECD countries (in 2000 the corresponding share was only one-fifth). The TFP contribution was more than 1 percentage point in only four countries (whereas in 2000 this was the case for nearly half of all OECD countries) and no major country is among them. The euro area stands out with a TFP growth contribution of only 0.2 percentage points in 2015.
- The recent contribution of capital deepening to trend productivity growth has not only declined, but remains weak in many countries: in 2015 it is estimated to be less than one quarter percentage point in one-third of OECD countries (compared to two countries with such a low contribution in 2000 and 2007); and more than 1 percentage point in only four countries (compared to 35 and 45% of countries in 2000 and 2007, respectively).

Figure 2. Explaining the change in trend labour productivity growth, 2000-07 and 2007-15

A. Contribution from capital deepening (% points per annum)
Frequency distribution of countries



B. Contribution from TFP growth (% points per annum)
Frequency distribution of countries



Note: The vertical axis denotes the number of OECD countries and the horizontal axis measures the percentage point per annum contribution to the change in trend productivity growth from either capital per worker (panel A) or TFP (panel B).
Source: OECD Economic Outlook 99 database.

12. The foregoing analysis, as previously emphasised, follows the current OECD methodology for computing potential output, however limited sensitivity analysis suggests that the main conclusions are qualitatively robust to computational details of how the capital stock is calculated within the same framework.[6] In particular, if the capital stock measure that is used in the production function is first smoothed, using a Hodrick-Prescott filter with the same parameter used to filter labour efficiency, then the

[6] This sensitivity analysis was conducted in response to concerns from a referee that the results might partly be an artefact of how the capital stock enters the production function unsmoothed.

importance of the decline in capital deepening in explaining the post-crisis decline in productivity growth remains:

- When using filtered capital, the contribution from capital per worker to trend productivity declines in 30 out of 34 countries between 2007 and 2015.
- When using filtered capital, the decline in capital per worker contributes more to the decline in trend productivity growth than TFP in more than two-thirds of countries between 2007 and 2015, whereas between 2000 and 2007 the contribution from the decline in capital per worker is greater than TFP in only one-fifth of countries.

Table 1. Trend productivity growth before and after the crisis

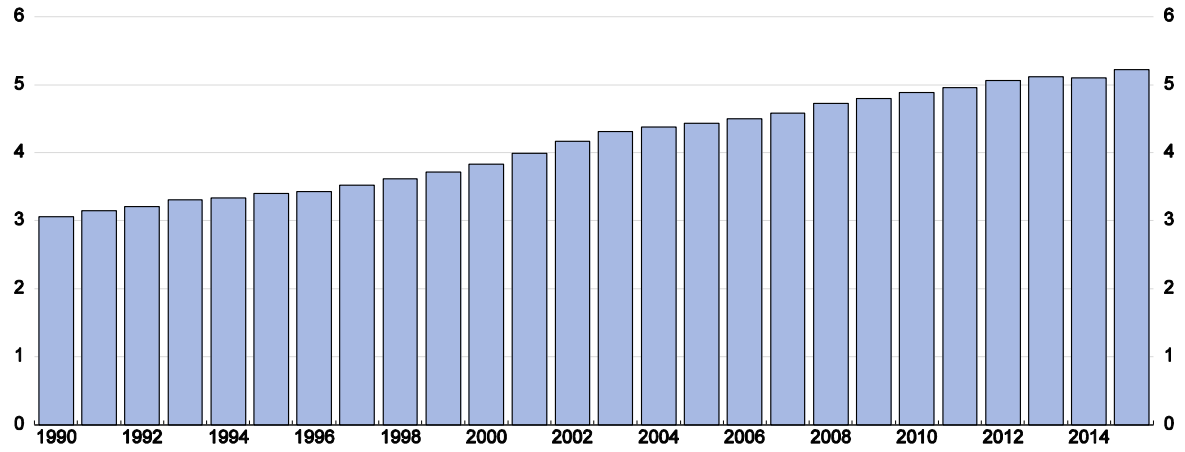
	(a) Trend productivity growth (% p.a.)					(b) Capital per worker contribution (% p.a.)					(c) TFP contribution (% p.a.)				
	(1A)	(2A)	(3A)	(4A) = (2A) - (1A)	(5A) = (3A) - (2A)	(1B)	(2B)	(3B)	(4B) = (2B) - (1B)	(5B) = (3B) - (2B)	(1C)	(2C)	(3C)	(4C) = (2C) - (1C)	(5C) = (3C) - (2C)
	2000	2007	2015	Change 2007 - 2000	Change 2015 - 2007	2000	2007	2015	Change 2007 - 2000	Change 2015 - 2007	2000	2007	2015	Change 2007 - 2000	Change 2015 - 2007
Australia	1.6	1.0	1.3	-0.6	0.3	0.2	0.8	0.7	0.6	-0.2	1.4	0.2	0.6	-1.2	0.5
Austria	1.6	0.8	0.1	-0.9	-0.6	0.7	0.4	0.1	-0.4	-0.3	0.9	0.4	0.1	-0.5	-0.3
Belgium	1.5	0.7	0.7	-0.8	0.0	0.6	0.3	0.3	-0.3	0.0	0.9	0.4	0.4	-0.5	0.0
Canada	1.3	0.8	0.9	-0.5	0.1	0.3	0.5	0.4	0.2	-0.1	1.0	0.3	0.5	-0.7	0.3
Switzerland	1.4	0.9	0.2	-0.6	-0.6	0.9	0.3	0.0	-0.5	-0.3	0.6	0.5	0.2	0.0	-0.3
Chile	2.5	1.5	1.1	-1.0	-0.4	1.9	1.8	1.4	0.0	-0.4	0.7	-0.3	-0.3	-0.9	0.0
Czech Republic	3.3	2.5	1.6	-0.8	-0.9	0.8	0.9	0.6	0.1	-0.3	2.5	1.6	1.0	-0.9	-0.6
Germany	1.1	0.6	0.2	-0.5	-0.4	0.4	0.1	-0.2	-0.3	-0.3	0.7	0.5	0.5	-0.2	-0.1
Denmark	1.7	0.6	0.5	-1.1	-0.1	0.8	0.6	0.1	-0.2	-0.5	0.9	0.0	0.4	-0.9	0.4
Spain	0.6	0.9	0.7	0.4	-0.2	0.7	1.1	0.7	0.5	-0.5	-0.1	-0.2	0.0	-0.1	0.2
Estonia	..	4.0	1.8	..	-2.2	2.3	3.4	1.2	1.2	-2.3	..	0.6	0.6	..	0.0
Finland	2.4	0.9	0.0	-1.5	-0.8	0.2	0.4	0.0	0.1	-0.4	2.1	0.5	0.1	-1.6	-0.5
France	1.1	0.8	0.5	-0.3	-0.4	0.4	0.5	0.1	0.1	-0.4	0.7	0.3	0.3	-0.4	0.0
United Kingdom	2.1	0.9	0.9	-1.1	0.0	1.0	0.9	0.5	0.0	-0.4	1.1	0.0	0.4	-1.1	0.4
Greece	2.7	0.5	-1.2	-2.2	-1.7	0.6	1.0	-0.2	0.4	-1.2	2.1	-0.5	-1.0	-2.6	-0.5
Hungary	3.6	2.2	1.2	-1.4	-1.0	1.4	1.5	0.8	0.2	-0.7	2.2	0.7	0.4	-1.5	-0.2
Ireland	3.2	2.6	2.5	-0.5	-0.2	1.1	1.6	1.6	0.6	-0.1	2.1	1.0	0.9	-1.1	-0.1
Iceland	2.6	2.8	1.0	0.2	-1.8	1.4	1.9	0.4	0.5	-1.5	1.2	0.9	0.6	-0.3	-0.3
Israel	1.5	0.8	0.6	-0.7	-0.2	1.2	0.4	0.3	-0.7	-0.1	0.3	0.4	0.3	0.0	-0.1
Italy	0.7	-0.2	-0.8	-0.9	-0.5	0.6	0.4	-0.3	-0.2	-0.7	0.1	-0.6	-0.4	-0.7	0.2
Japan	1.2	0.8	0.6	-0.4	-0.2	0.8	0.4	0.1	-0.4	-0.3	0.4	0.4	0.5	0.0	0.1
Korea	3.9	2.8	1.9	-1.0	-0.9	1.9	1.3	0.7	-0.6	-0.5	2.0	1.6	1.2	-0.4	-0.4
Luxembourg	0.9	0.0	0.2	-0.9	0.2	0.3	-0.2	-0.2	-0.4	0.0	0.6	0.2	0.4	-0.4	0.2
Mexico	1.2	0.2	1.2	-1.0	1.0	1.2	1.0	0.8	-0.2	-0.2	-0.1	-0.8	0.4	-0.8	1.2
Netherlands	1.6	0.8	0.6	-0.9	-0.1	0.9	0.6	0.3	-0.2	-0.3	0.8	0.2	0.4	-0.6	0.2
Norway	2.1	1.8	0.6	-0.3	-1.2	0.7	1.1	0.4	0.4	-0.7	1.5	0.7	0.2	-0.8	-0.5
New Zealand	1.2	0.9	0.6	-0.3	-0.3	0.2	0.7	0.3	0.6	-0.4	1.0	0.1	0.3	-0.9	0.1
Poland	5.2	3.0	2.5	-2.3	-0.5	2.0	1.3	1.0	-0.7	-0.3	3.3	1.7	1.5	-1.6	-0.2
Portugal	2.1	1.3	0.4	-0.8	-0.8	2.0	1.4	0.3	-0.6	-1.1	0.1	-0.1	0.2	-0.2	0.3
Slovak Republic	3.8	4.6	1.8	0.8	-2.7	0.8	1.6	0.7	0.8	-0.8	3.0	3.0	1.1	0.0	-1.9
Slovenia	3.0	2.1	1.2	-1.0	-0.8	1.3	1.4	0.4	0.1	-1.0	1.7	0.7	0.8	-1.1	0.2
Sweden	2.8	1.5	0.9	-1.3	-0.6	0.8	0.5	0.2	-0.3	-0.3	1.9	0.9	0.7	-1.0	-0.2
Turkey	2.3	2.8	1.0	0.4	-1.8	1.3	2.1	0.5	0.8	-1.5	1.1	0.7	0.5	-0.4	-0.2
United States	2.0	1.5	1.0	-0.5	-0.5	0.8	0.6	0.3	-0.2	-0.3	1.1	0.9	0.7	-0.2	-0.2
Euro area	1.2	0.7	0.3	-0.5	-0.4	0.5	0.5	0.1	0.0	-0.4	0.6	0.2	0.2	-0.4	0.0
OECD total	1.7	1.1	0.8	-0.6	-0.4	0.8	0.6	0.2	-0.3	-0.4	0.9	0.6	0.6	-0.4	0.0
OECD median	2.0	0.9	0.8	-1.1	-0.1	0.8	0.9	0.3	0.0	-0.5	1.0	0.4	0.4	-0.6	0.0

Source: OECD Economic Outlook 99 database.

4. Causes of the weakness in capital stock growth

13. The slowdown in the contribution of capital to productivity growth is, in an accounting sense, due both to a declining investment rate and to a trend rise in scrapping rates (Figure 3).[7] The trend rise in scrapping rates reflects a change in the asset composition of capital towards assets which have shorter lives, such as ICT-related assets. However, the trend rise in the scrapping rate clearly pre-dates the financial crisis and shows no sign of accelerating following the crisis. Instead, the current section focuses on explanations for the post-crisis weakness in investment, so ignoring long-run influences on investment such as changing asset composition or other factors such as ageing population or global warming.

Figure 3. OECD capital stock depreciation rate



Source: OECD Economic Outlook 99 database.

4.1. The contribution of weak demand

14. The collapse in demand precipitated by the financial crisis, as well as its persistent weakness and uncertain outlook since, is perhaps the most obvious reason why investment has been so weak given that empirically estimated investment equations are usually dominated by 'accelerator' effects operating through demand. A recent chapter on investment in the OECD Economic Outlook reported "*New OECD empirical analysis based on a model linking investment with GDP confirms the importance of output developments in explaining movements in business investment… the model largely tracks the downturn in investment at the height of the crisis and the dynamics in recent years. So it remains the case that the predominant factor associated with sluggish investment since the crisis is persistently weak output developments*" OECD (2015b). This implies that severe and prolonged weakness in demand can lead to a sustained period of weak

[7] The scrapping rate here corresponds to national accounts related measures of depreciation which weight together scrapping rates on different asset types. It does not attempt to quantify capital that became economically redundant as a consequence of the financial crisis and in that sense may under-estimate the decline in capital accumulation following the crisis.

investment, which in turn weakens productivity and potential output via its supply-side effect on the capital stock.

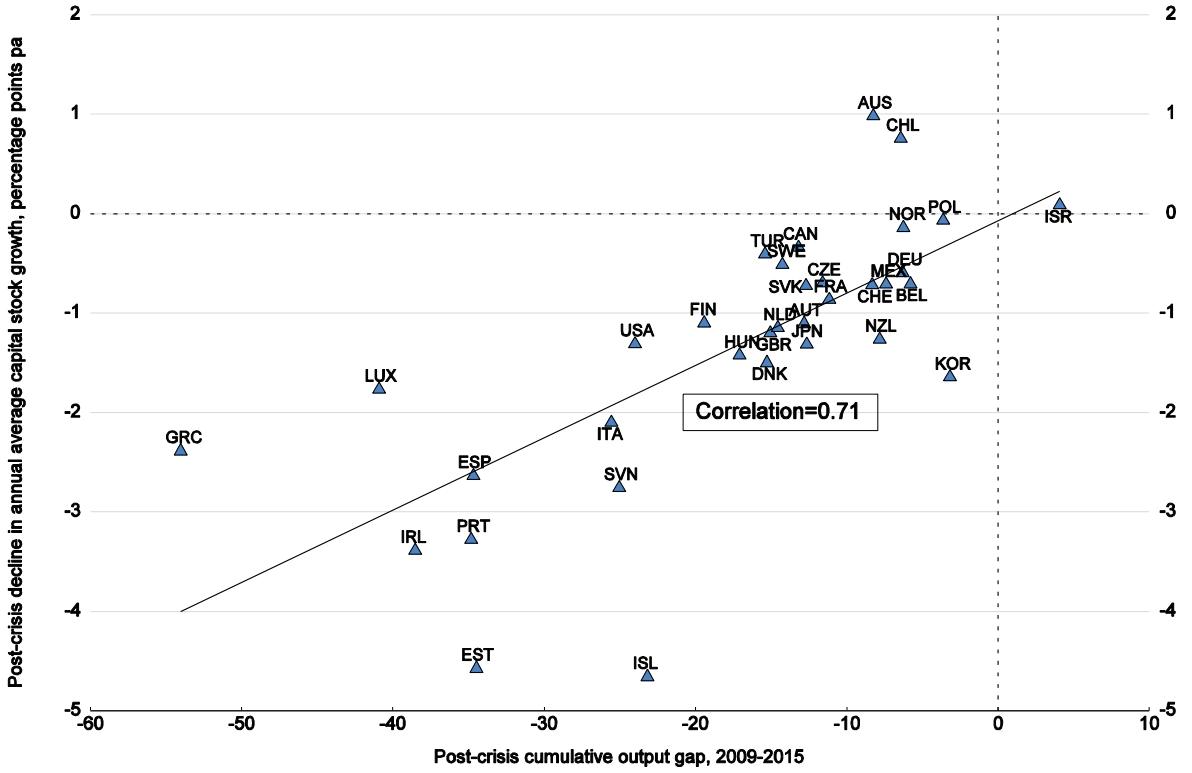
15. To illustrate the possible magnitude of this hysteresis-like effect, a simple model is constructed by combining a recently estimated pooled investment equation for OECD countries with equations for potential output and the output gap, and applying shocks to the model that mimic the effect of the financial crisis on output gaps (Box 1). The results suggest that, among the 19 OECD countries that experienced a banking crisis,[8] the demand shock associated with the financial crisis may have typically reduced the capital stock by about 3½ per cent and for the most severely affected countries in the lowest quartile by more than 6%. This in turn generates a peak loss in potential output of more than 1% for the typical OECD country and by more than 2% for the more severely affected countries. More specifically, this would suggest that Ireland, Luxembourg, Iceland, the United Kingdom and the United States experienced a peak loss in potential output of between 1 and 2% as a direct consequence of the accelerator response of investment to the demand shock. For the most severely affected countries – Italy, Portugal, Greece, Slovenia and Spain – the peak loss in potential output is more than 2%. The implied reduction in the average growth rate of the capital stock explains about half of the reduced contribution from capital deepening to trend productivity growth observed since the crisis.

16. Formally, the model described in Box 1 implies there will be no permanent long-run damage to potential output, but, as demonstrated in the simulation, the adverse effect of a prolonged slump can reduce potential output growth over decades, thus giving the impression of hysteresis-like weakness in both capital accumulation and productivity. Using a more elaborate model calibrated on the United States, Hall (2016) also concludes that depletion of the capital stock is the most important of the mechanisms propagating the shock represented by the financial crisis of 2008.

17. The calibrated simulation in Box 1 is intended to reflect typical changes in the output gap for a typical OECD country following the financial crisis. However, although causality cannot be inferred from a scatter plot, cross-country evidence suggests that countries which experienced the largest cumulative output gap following the crisis also experienced the most pronounced slowdown in capital stock growth (Figure 4).

[8] The 19 OECD countries which are identified by Laeven and Valencia (2012) as having experienced a banking crisis over the period 2007-2011 are Austria, Belgium, Denmark, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Switzerland, the United Kingdom and the United States.

Figure 4. The slowdown in capital growth and the shock to demand



Source: OECD Economic Outlook 99 database.

Box 1. Simulating the interaction between investment and potential output

This box sets out a 4-equation calibrated dynamic model to simulate the interaction between investment and potential output for a typical OECD country.

The quarterly model is based on a standard Cobb-Douglas production function, as described in Section 2 (equation [1]), where y* is potential output, n is the labour input, e is labour efficiency and k is the capital stock (all in logs). The second equation defines the output gap (GAP) as the difference between actual and potential real output. The third equation, inspired by the OECD long-term scenarios model discussed in Johansson et al. (2013), ensures that any output gap closes smoothly over a few years and includes an error term (ε) to allow the output gap to be calibrated. Finally, the last equation determines the dynamics of the capital stock and is calibrated based on the results from pooled estimation across 15 OECD countries in Appendix 1 of OECD (2015a), with short-term dynamics that include one lag of the change in the capital stock, three lags of the change in actual output and an error-correction term that respects the estimated long-run elasticity of capital to output of 1.23. For simplicity, other variables in the estimated equation are dropped (see Tables 3.A1.2 and 3.A1.3 of OECD, 2015a), except the lagged change in foreign output, whose coefficient is assumed to apply to (and is added to the coefficient on) domestic output. The real interest rate is not included in the equation because the original empirical work was unable to find a correctly-signed effect. Other variables, for example capturing the effect of financial constraints or uncertainty, while statistically significant, have much less economic importance than output when judged in terms of the effect from a one-standard deviation shock.

$$y_t^* = \frac{2}{3}(n_t + e_t) + \frac{1}{3}k_t \quad [1]$$

$$y_t = y_t^* + GAP_t \quad [2]$$

$$GAP_t = 0.96 \cdot GAP_{t-1} - 0.07 \cdot GAP_{t-2} + \varepsilon_t \quad [3]$$

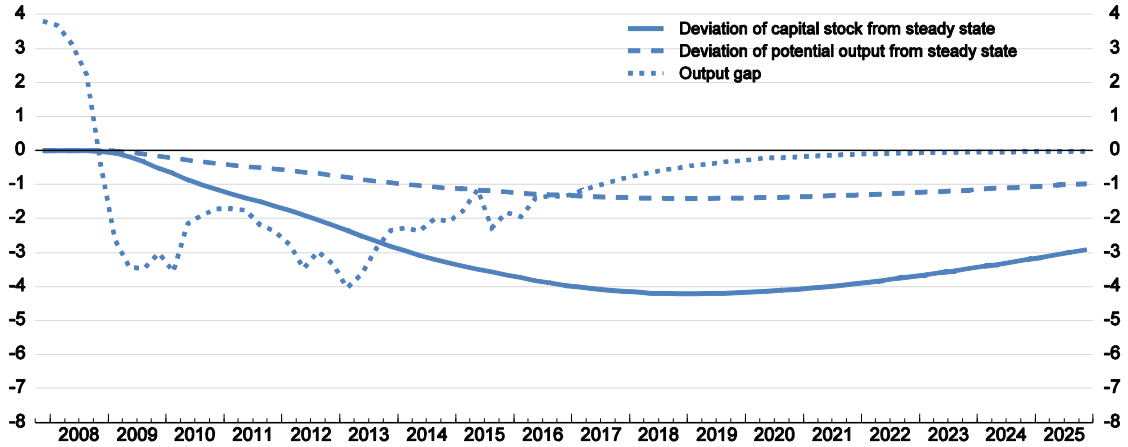
$$\Delta k_t = 0.95 \cdot \Delta k_{t-1} + 0.015 \cdot \Delta y_{t-1} + 0.006 \cdot \Delta y_{t-2} + 0.004 \cdot \Delta y_{t-3} - 0.002 \cdot (k_{t-1} - 1.23 \cdot y_{t-1}) \quad [4]$$

The model is shocked by calibrating the error term in equation [3] so that the output gap follows a path corresponding to a particular profile of the output gap from the last quarter of 2007 to the end of 2016. Two alternative profiles for the output gap are considered: the first (panel A) corresponds to the typical post-crisis response as represented by the median output gap among the 19 OECD countries experiencing a banking crisis; the second (panel B) represents the most severely affected countries and corresponds to the lower quartile output gap response among the same group of OECD countries. Other variables are determined by the model and so is the output gap after 2016. In the simulation, which starts in the last quarter of 2008, the fall in output from end-2007 and the persistent negative output gap drag the capital stock down by a maximum of about 4% per cent below the steady-state value for the median output gap shock and by 6% for the lower quartile output shock (see the charts below). Moreover, these falls in the capital stock lower potential output by nearly 1½ per cent below its equilibrium for the median output gap shock and by more than 2% for the lower quartile output gap shock. Thus, to the extent that the model's calibration is empirically valid, a substantial part of the downward revisions to potential output and trend labour productivity since the crisis can be attributed to weak investment.

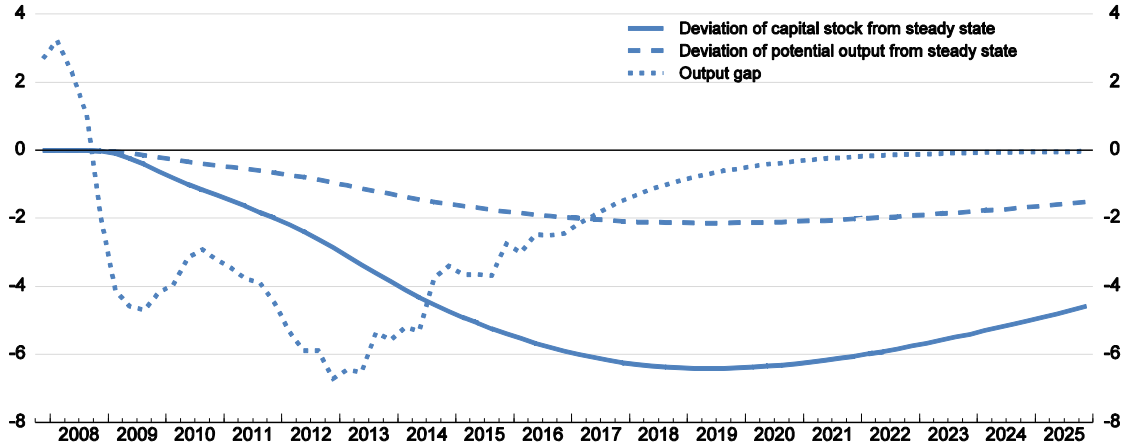
Box 1. Simulating the interaction between investment and potential output *(contd.)*

Box Figure. The impact of weak investment on the capital stock and potential output

A. Median output gap response, per cent



B. Lower quartile output gap response, per cent

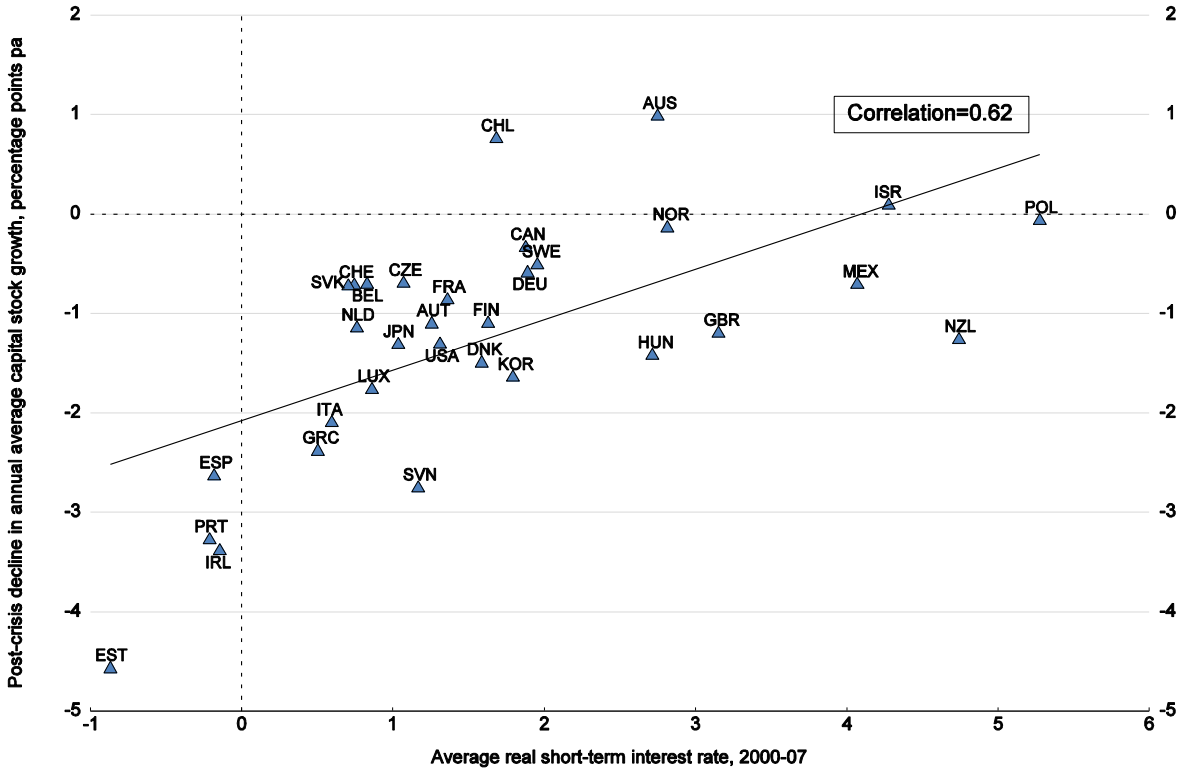


Note: The two panels show the response of the model described by equations [1] to [4] to different output gap shocks, where panel A represents the median output gap response across all countries and panel B represents more severely affected countries as represented by the lower quartile output gap response.
Source: OECD calculations using the OECD Economic Outlook 99 database.

4.2. The contribution from the pre-crisis misallocation of capital

18. Increasing evidence, especially from firm-level studies, suggests that many countries where interest rates were particularly low in the pre-crisis period, particularly in Southern Europe, experienced a substantial misallocation of capital in the pre-crisis period [Gopinath et al (2017); Gamberoni et al (2016); Garcia-Santana et al. (2016); Calligaris (2015); Dias et al (2014)]. This suggests that a complementary explanation for the weakness of investment in the post-crisis period is that it partly reflects the 'hangover' from the misallocation of resources which occurred in the pre-crisis period (Borio et al., 2015). The misallocation of capital was characterised by housing and construction booms in many countries and in some EU countries may have been facilitated by the inefficient use of EU funds. Those countries which experienced the lowest short-term real interest rates over the pre-crisis period – most notably Estonia, Greece, Ireland, Portugal and Spain – were those which experienced the sharpest slowdown in capital stock growth in the post-crisis period (Figure 5). Distinguishing the extent to which the post-crisis decline in investment is a response to the adverse demand shock or a pre-crisis misallocation would be possible if the analysis explicitly identified the trend capital stock. However, as previously discussed, the current OECD approach to estimating potential output does not do so, particularly because it is so difficult to identify the trend capital stock.

Figure 5. The slowdown in capital growth and pre-crisis real interest rates



Note: Excludes Iceland and Turkey.
Source: OECD Economic Outlook 99 database.

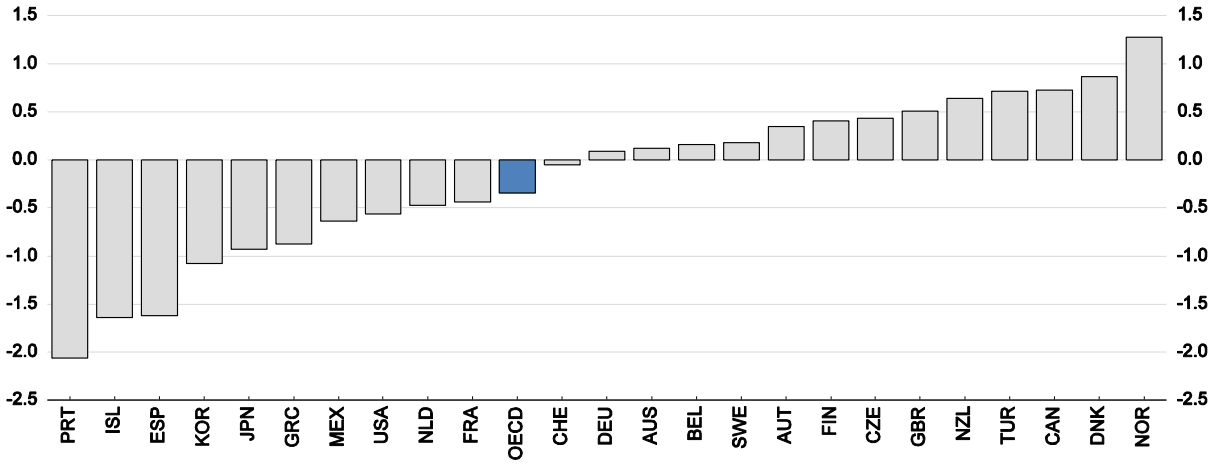
4.3. The contribution of public investment

19. To the extent that macro policy responses, especially from monetary policy, have cushioned the post-crisis downturn, they may have helped to limit the damage to potential growth, although empirical evidence of the beneficial effects of lower interest rates on investment is surprisingly meagre (OECD, 2015b).

20. The most direct contribution of policy to growth of the whole-economy capital stock comes from government investment, and it has fallen as a share of GDP compared with pre-crisis levels for the OECD as a whole and among nearly half of OECD countries for which data are readily available (Figure 6). Among those countries shown in Figure 6 for which government investment has fallen as a share of GDP relative to a pre-crisis average, the fall in government investment typically accounts for more than one-fifth of the fall of the share of total investment in GDP. Those countries where government investment was cut back most sharply are also those where growth of the whole-economy capital stock declined the most (Figure 7). The correlation between government investment and the change in post-crisis capital stock growth may partly reflect the fact that many of the countries that were most severely affected by the crisis – including Iceland, Greece, Portugal and Spain – were also under the most pressure to undertake fiscal consolidation measures. Indeed, cuts to public fixed investment accounted for about one-fifth of the consolidation effort between 2009 and 2012 in the euro area, the United Kingdom and the United States, and as much as two-fifths in Spain, despite advice to the contrary from the OECD and others (OECD, 2013).

Figure 6. Change in government investment

2015 relative to average over 2000-07, percentage of GDP

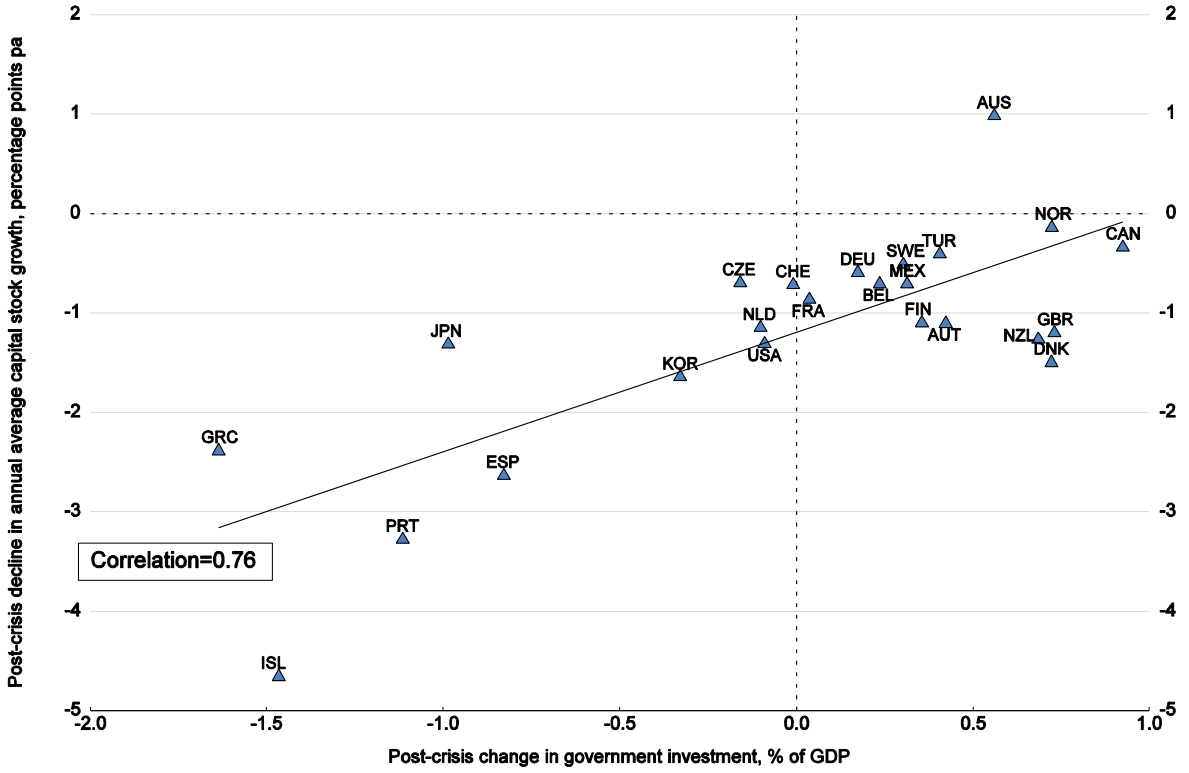


Source: OECD Economic Outlook 99 database.

21. Falling government investment may not only have contributed to a direct reduction in the growth rate of the productive capital stock, but may also have had adverse indirect spillover effects on business investment and productivity. A recent meta-analysis by Bom and Lighart (2014) suggests that the effect of public investment on private sector investment and activity is positive, being larger for: public capital installed by local/regional governments; core public capital (roads, railways, utilities, etc.); and at longer horizons. There is also much existing literature to suggest that public investment

can boost long-term growth, particularly where market failures lead to under-investment in the private sector (IMF, 2015). Moreover, recent OECD empirical work suggests a large positive effect of public investment on productivity (Fournier and Johansson, 2016).

Figure 7. The slowdown in capital stock growth and the post crisis change in government investment



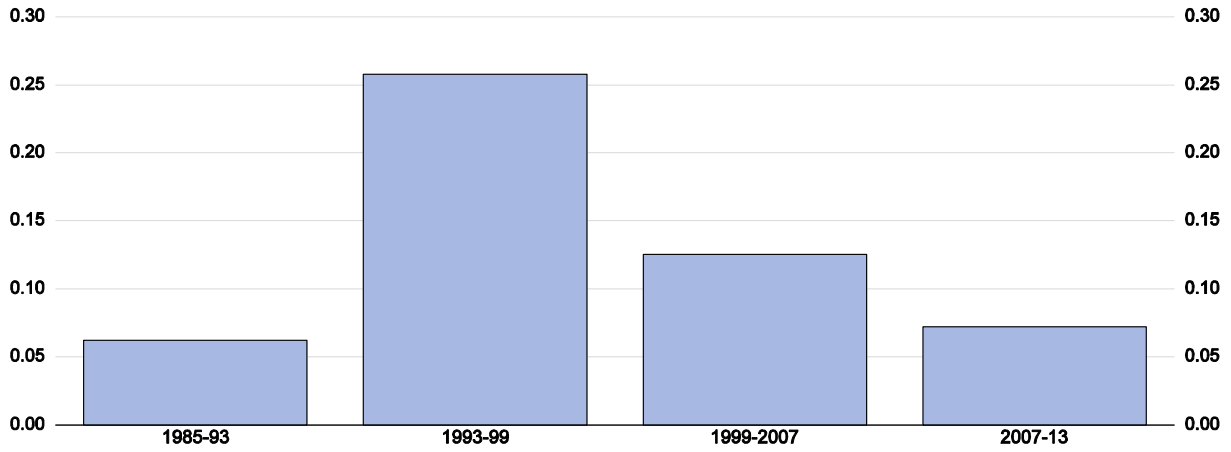
Source: OECD Economic Outlook 99 database.

4.4. The contribution from product market regulation reforms

22. Among the many factors contributing to weak investment and productivity growth, many can be summarised under the "fragmentation" headline: the heterogeneous policies, rules, laws and industry practices that create perverse incentives and block business efficiency and productivity growth (OECD, 2016b). More narrowly, recent empirical work in the Economics Department suggests that structural reforms which promote competition in product markets tend to boost capital intensity, albeit with long lags (OECD, 2015b; Égert, 2016; and Égert and Gal, 2016). However, while competition-enhancing product market regulation has continued to improve, the rate of improvement has declined in the post-crisis period (Figure 8). Given the bounded nature of the OECD index measuring product market regulation, rapid improvement cannot be sustained in all countries. However, in most OECD countries, a significant gap with the best performing countries remains, suggesting further scope for improvement. Thus, over a period in which the use of macro policy instruments has been constrained, the waning enthusiasm for structural reform represents a missed opportunity.

Figure 8. Improvement in product market

Average annual change in the OECD median indicator score for product market regulation in the network industries



Source: OECD PMR database.

5. Conclusions

23. While the long-standing decline in trend productivity growth in OECD countries predates the financial crisis, analysis based on the potential output framework used by the OECD suggests that prior to the crisis this was mainly explained by falling TFPtfp growth, whereas after the crisis it was mainly explained by a declining contribution from capital per worker

24. A simple empirically-based model suggests that much of the post-crisis weakness in capital growth, and hence potential output, can be explained by a hysteresis-like response to weak demand. In the most severely affected OECD economies, potential output is estimated to have been reduced by more than 2% via this transmission mechanism. This provides wider cross-country support for the sort of persistent effects from aggregate demand on supply alluded to in the quote from Janet Yellen referred to in the introduction.

25. The evidence for hysteresis–like effects from investment on potential output provides a further rationale for counter-cyclical macroeconomic policy following a severe downturn. On the other hand, increasing evidence of capital misallocation in the pre-crisis period, cautions against policymakers trying to exploit this result by deliberately allowing the economy to overheat. The paper also suggests that in many OECD countries, there was greater scope to use government investment and product-market reforms to further counteract the damage to supply potential from the financial crisis.

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Annex A. COUNTRY-SPECIFIC DECOMPOSITIONS OF GROWTH OF TREND LABOUR ACTIVITY

This appendix provides a set of charts, one for each OECD country, decomposing the growth in trend labour productivity using the current OECD framework for estimating potential output. This framework assumes a Cobb-Douglas production function, whereby potential output (Y*) is expressed in terms of potential employment (N*), the capital stock (K) and labour-augmenting trend technical progress (E*), so that:

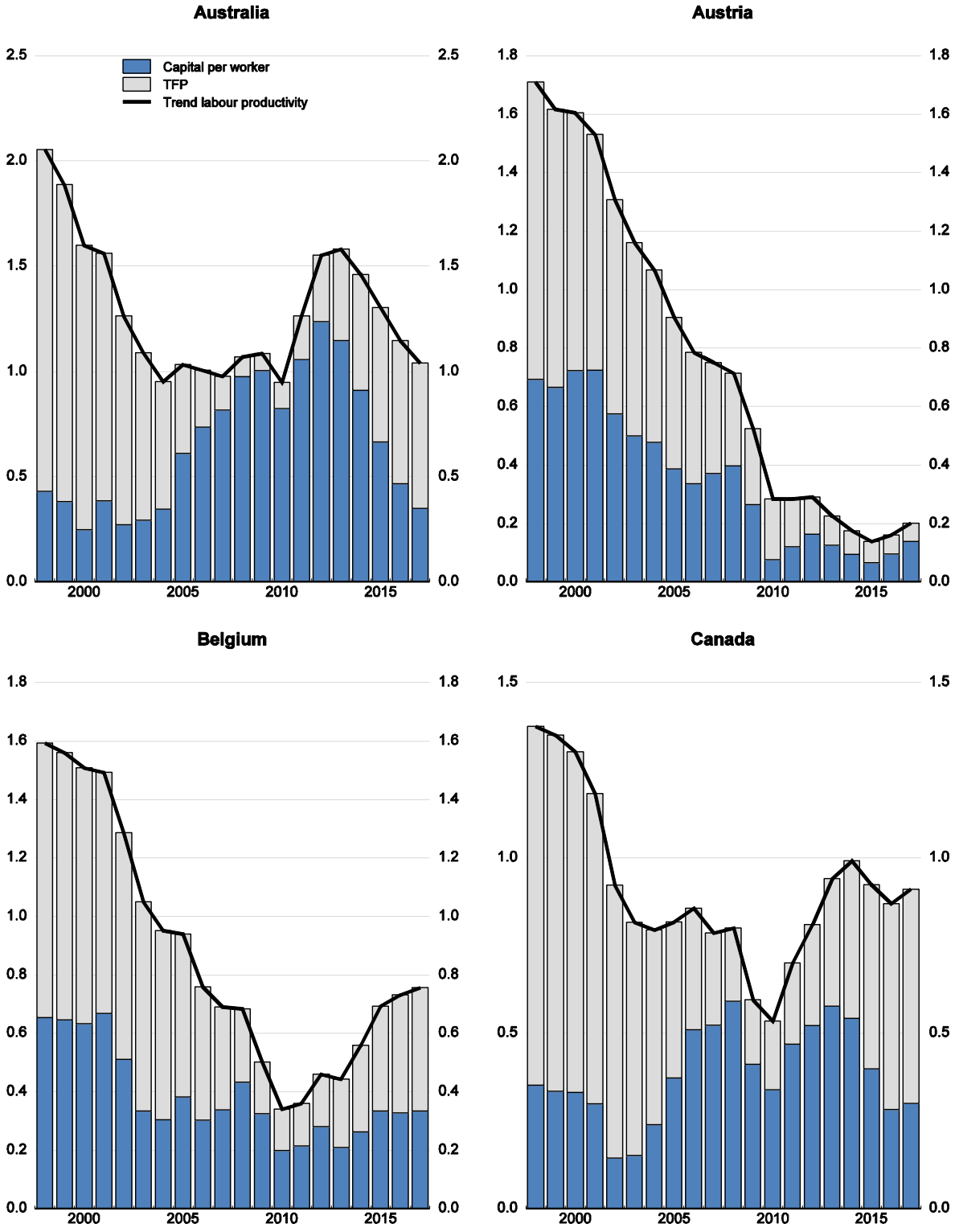
$$y^* = \alpha (n^* + e^*) + (1 - \alpha) k, \qquad [A.1]$$

where lower case letters denote logs and α is the wage share. Total factor productivity growth (TFP) is a simple transformation of labour efficiency: $tfp = \alpha e^*$.

An expression for trend labour productivity growth, defined as potential output divided by potential employment component, can be derived from re-arranging [A.1], where Δ is the first difference operator and the first term on the right-hand-side represents the contribution from tfp growth and the second term the contribution from growth in capital per worker:

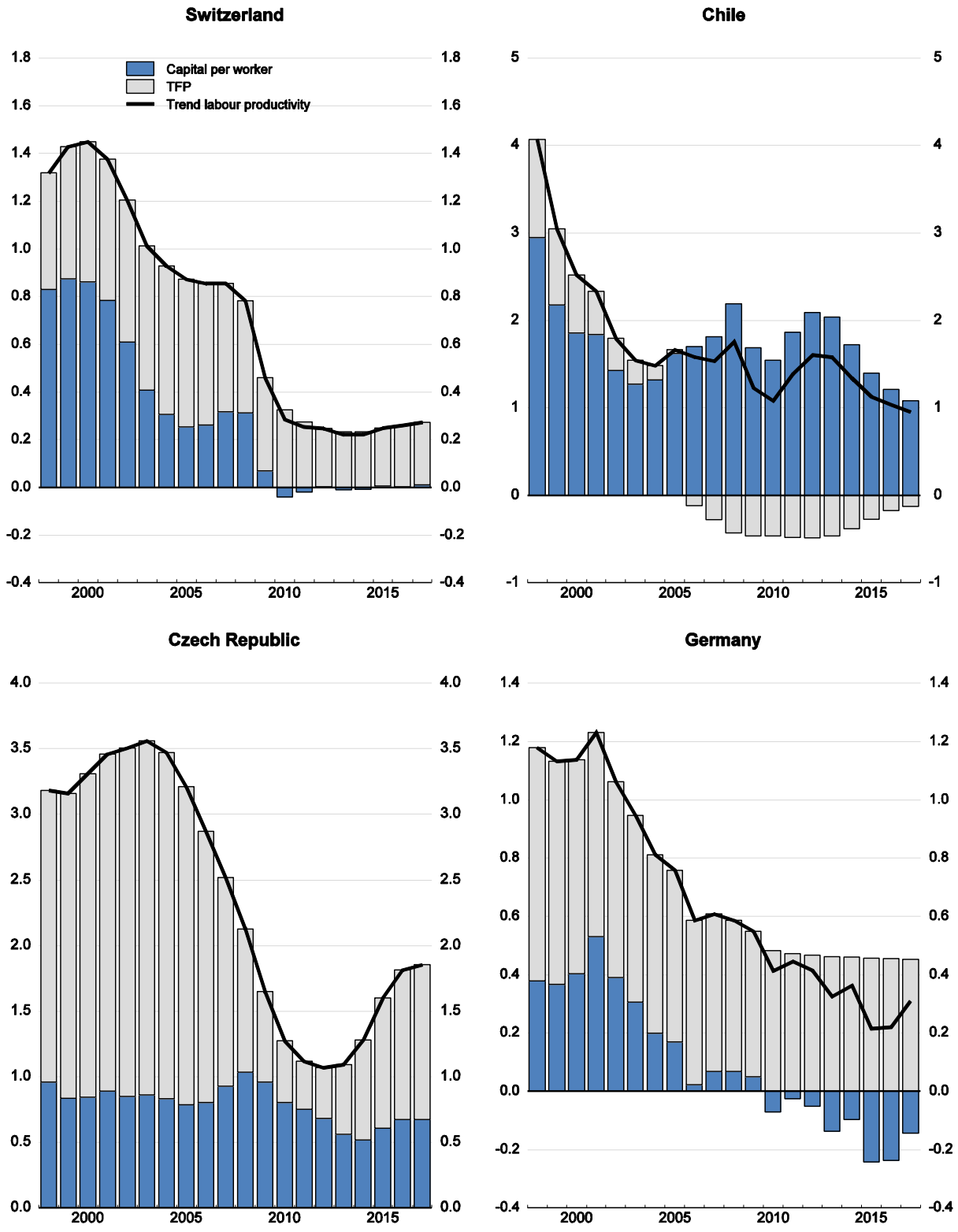
$$\Delta(y^* - n^*) = \alpha \Delta e^* + (1 - \alpha) \Delta(k - n^*). \qquad [A.2]$$

Figure A.1. Decomposition of growth of trend labour productivity



Source: OECD Economic Outlook 99 database

Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)



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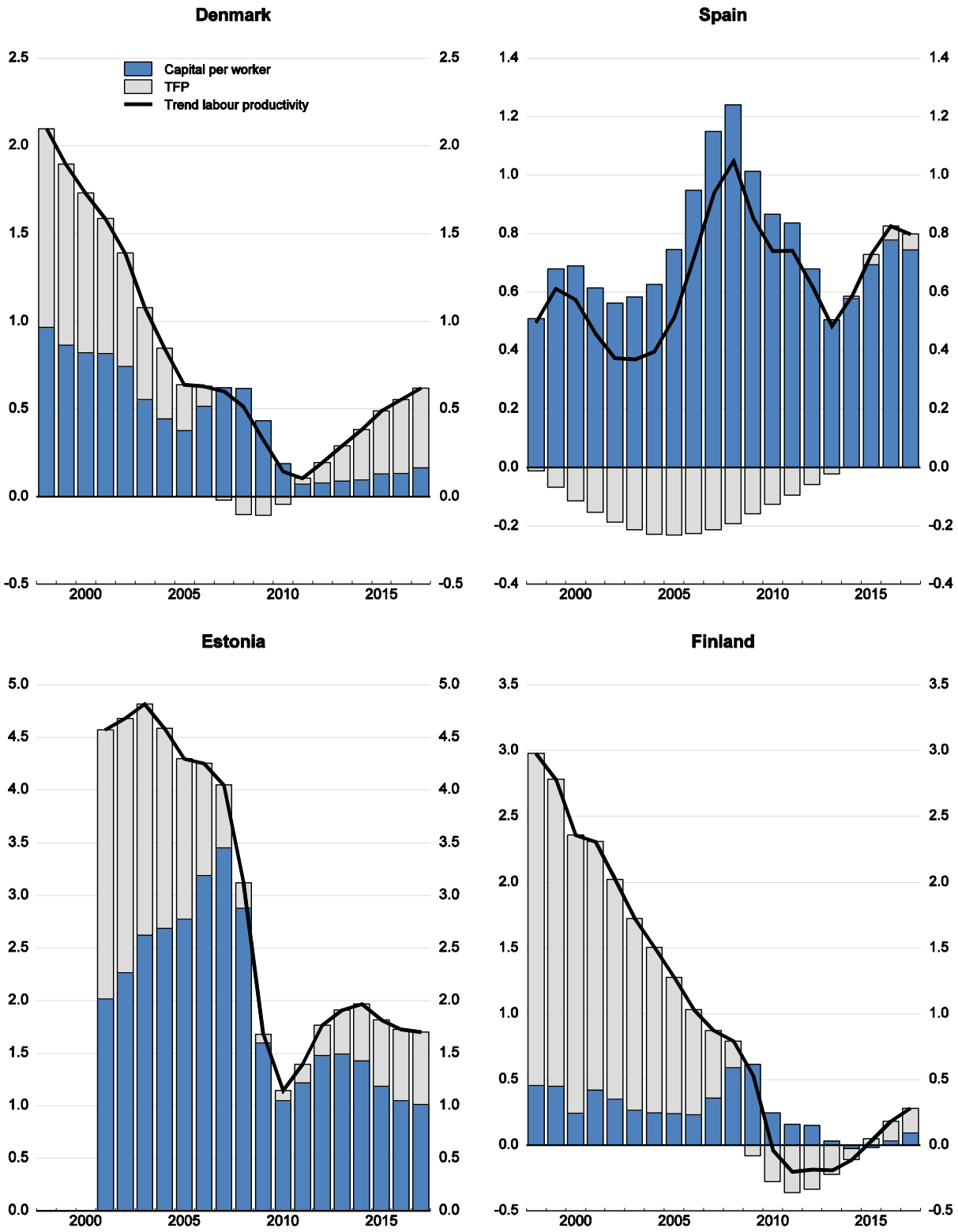

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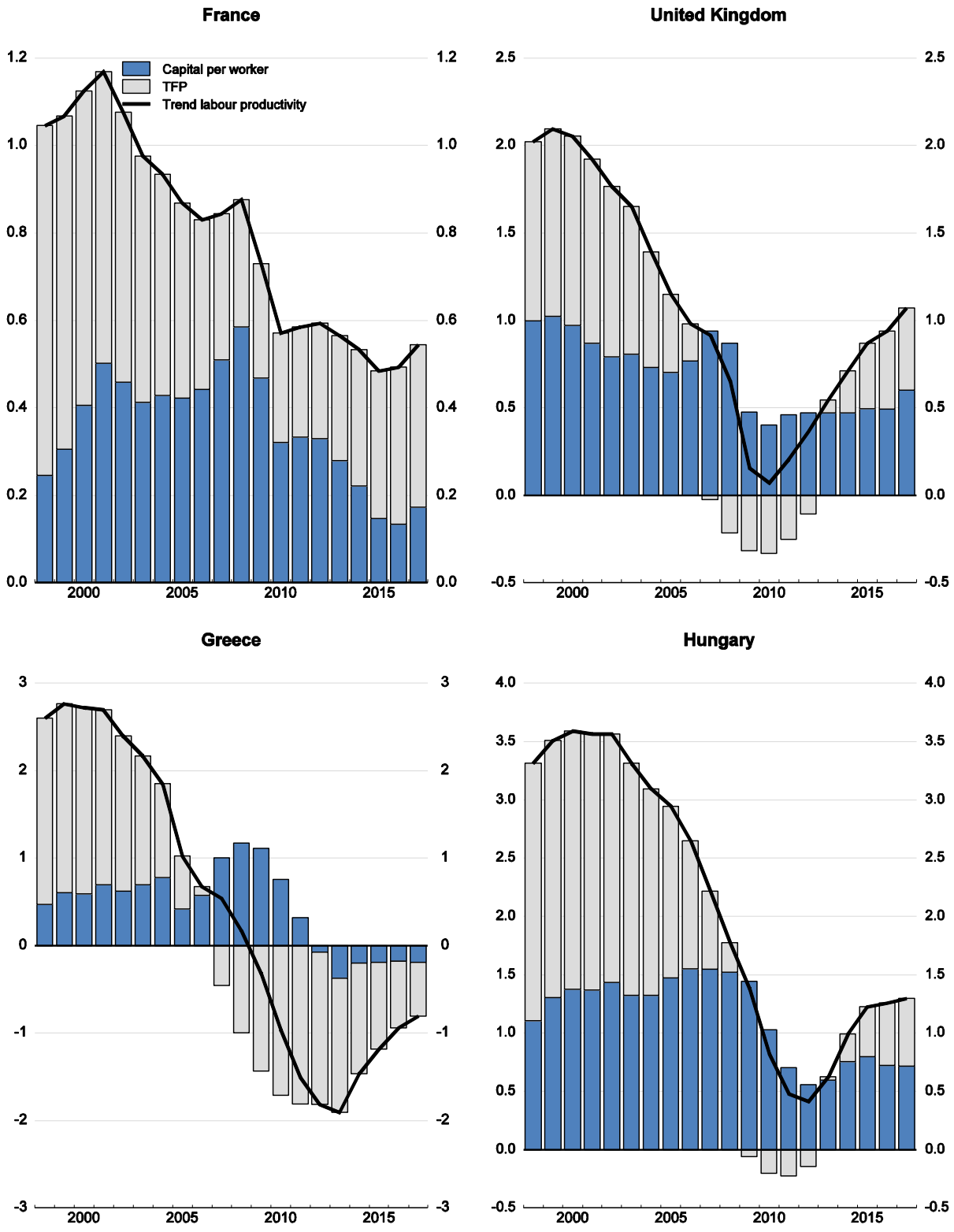

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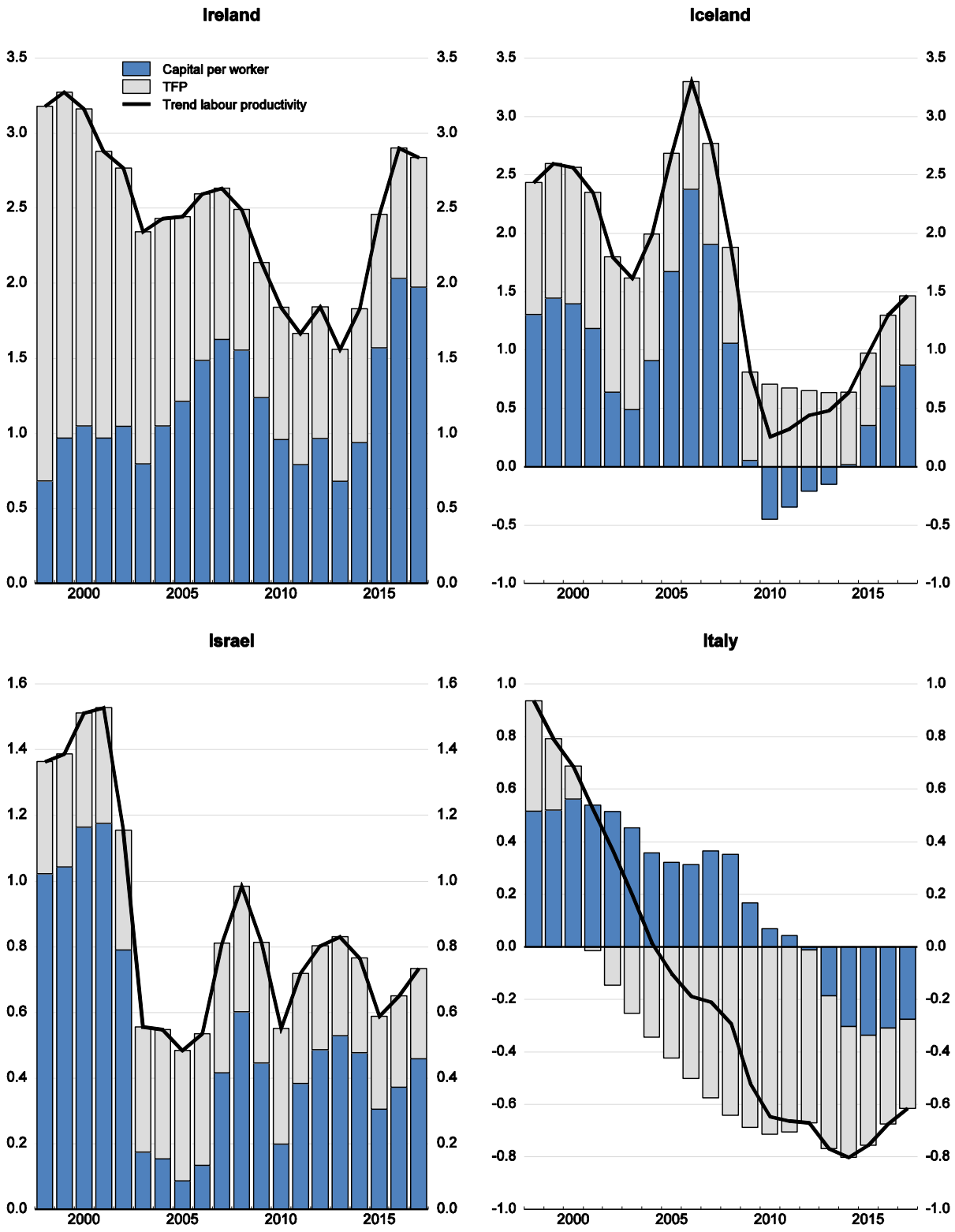
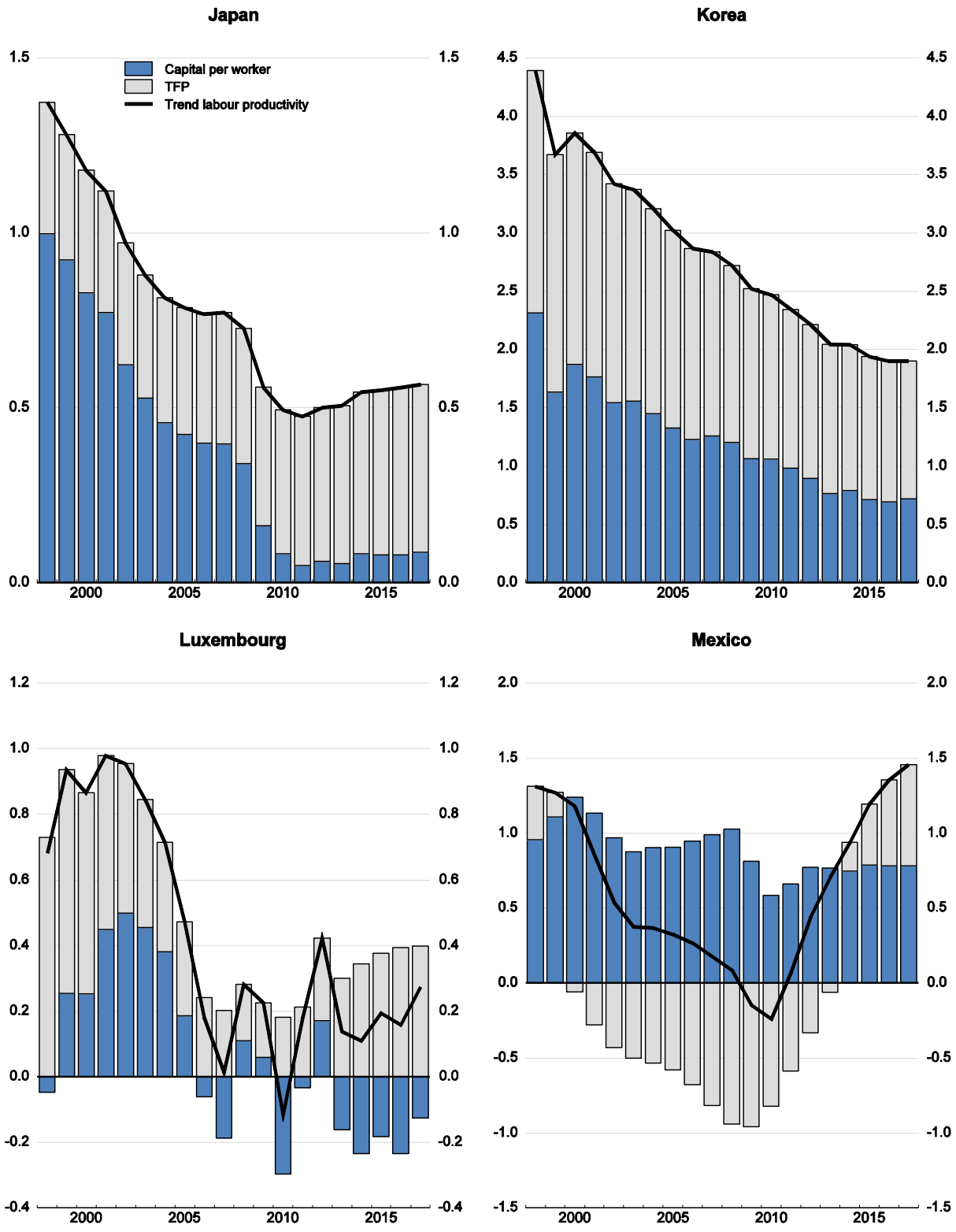
Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)



Source: *OECD* Economic Outlook 99 database

Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)



Source: OECD Economic Outlook 99 database.

Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)

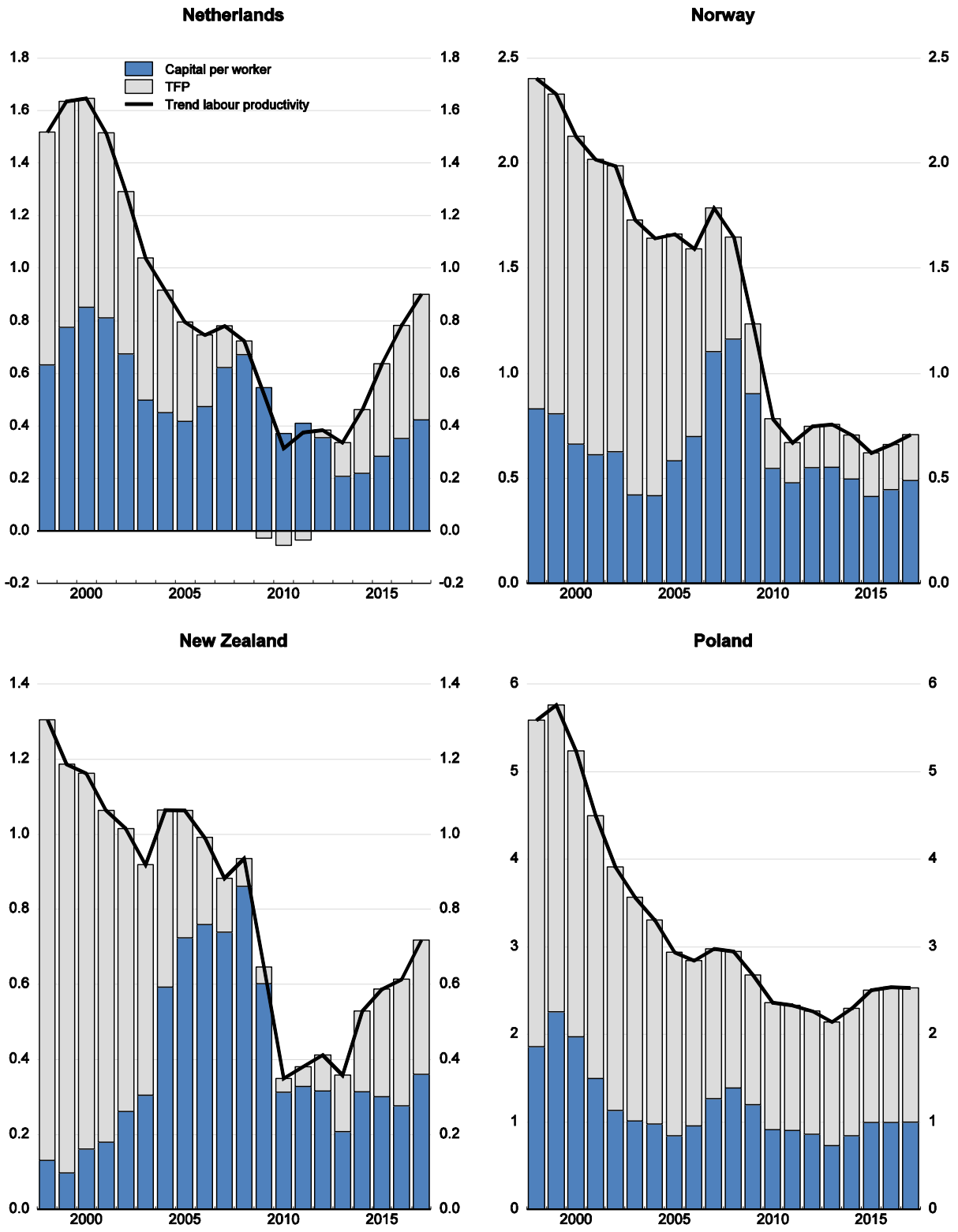


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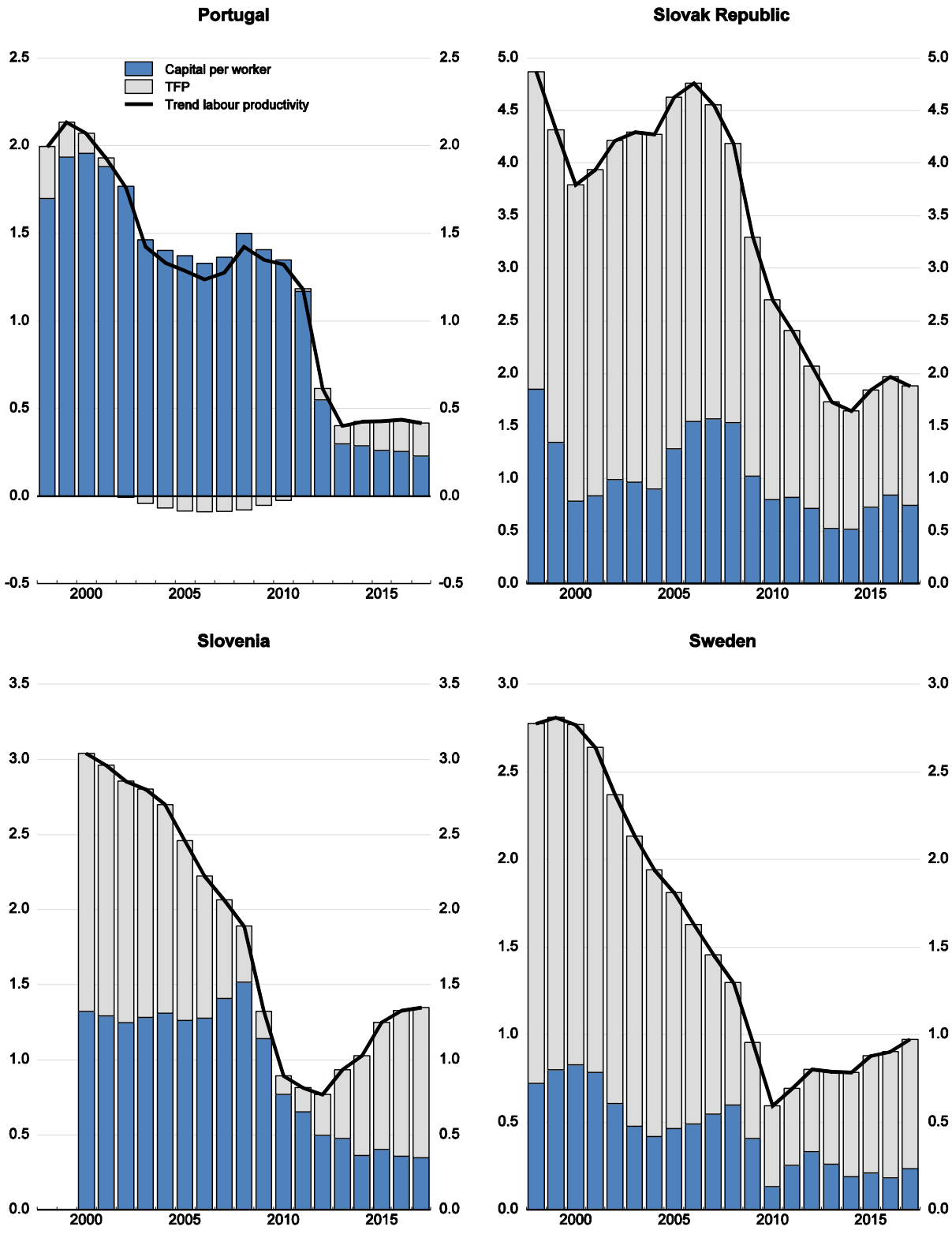
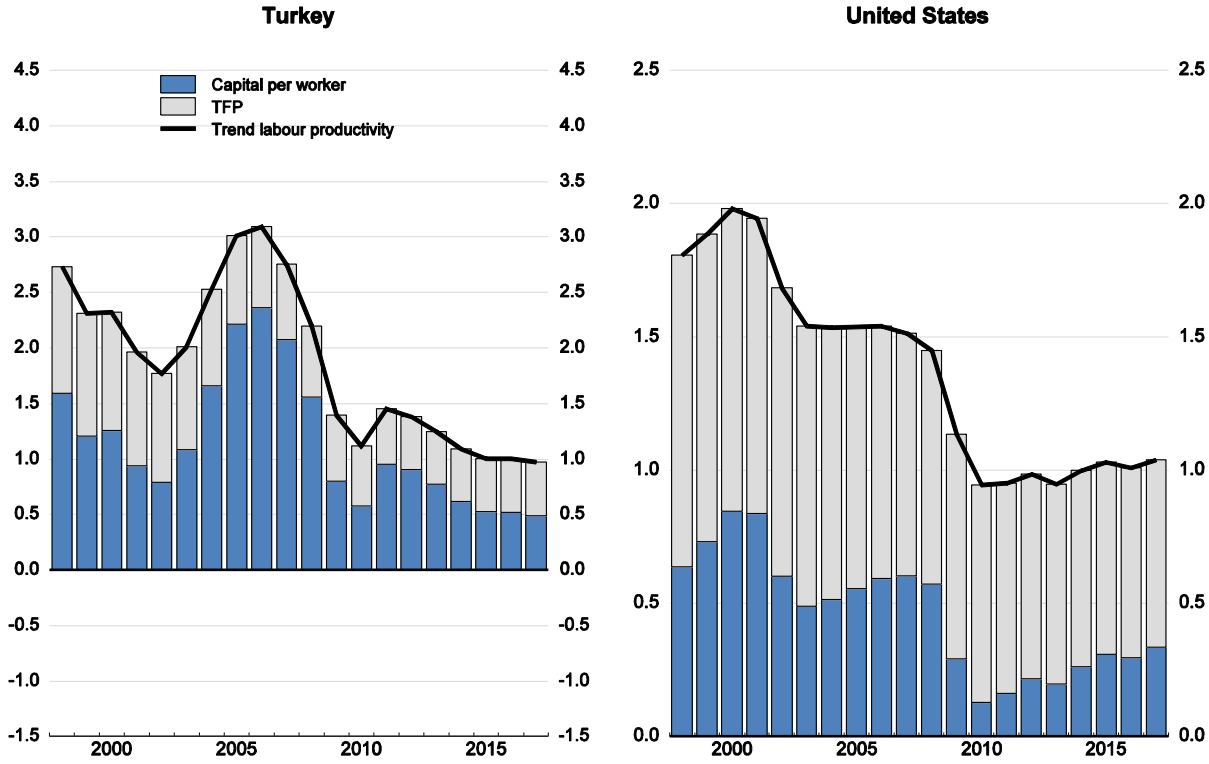
Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)



Source: OECD Economic Outlook 99 database.

Figure A.1. Decomposition of growth of trend labour productivity (*contd.*)



Source: OECD Economic Outlook 99 database