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GAUGING THE IMPACT OF HIGHER CAPITAL AND OIL COSTS ON POTENTIAL OUTPUT

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by Boris Cournède

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ABSTRACT/RÉSUMÉ

Gauging the impact of higher capital and oil costs on potential output

The 2007-2009 period has been characterised by an oil shock followed by a financial crisis. Higher oil prices and the prospect of higher borrowing costs are likely to reduce the productive potential of OECD economies. The present study provides illustrative numerical estimates of the impact under different scenarios using a stylised model based on a production function. In a scenario where real borrowing costs for firms return to their 1991-2001 average as opposed to staying at the level at which the capital stock in place at the end of 2007 had been invested, the impact on equilibrium GDP could be in the order of 2%. If the real oil price stays at $80 per barrel, up from the $50 average at which the capital stock in place in 2007 had been invested, the impact on equilibrium GDP could be in the order of 1%.

JEL classification: E22; E23.
Keywords: financial crisis; interest rates; oil price; capital costs; oil shock; potential output; potential growth; partial equilibrium; general equilibrium; United States; euro area.

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Une évaluation de l'impact de l'augmentation des coûts du capital et du pétrole sur le potentiel de production

La période 2007-2009 a été caractérisée par un choc pétrolier suivi d'une crise financière. Des prix de l'énergie plus élevés et la perspective d'un renchérissement du coût du crédit réduisent probablement le potentiel productif des pays de l'OCDE. La présente étude propose d'illustrer ces effets par des évaluations numériques s'appuyant sur un modèle stylisé construit à l'aide d'une fonction de production. Le principal résultat est que ces deux chocs peuvent avoir un impact significatif, quoique d'une taille très incertaine. Dans un scénario où le coût réel des prêts aux entreprises reviendrait à sa moyenne sur la période 1991-2001, le PIB d'équilibre pourrait s'en trouver réduit d'environ 2%, par comparaison à une situation dans laquelle le coût réel du crédit demeurerait au niveau moyen auquel le capital en place à la fin de 2007 fut investi. Si le prix du brut restait voisin de 80 dollars par baril, et par comparaison au prix moyen de 50 dollars qui prévalait lorsque le capital en place en 2007 fut investi, l'impact sur le PIB d'équilibre pourrait être de l'ordre de 1%.

Classification JEL : E22 ; E23
Mots clés : crise financière ; taux d'intérêt ; prix du pétrole ; coût du capital ; choc pétrolier ; potentiel de production ; croissance potentielle ; équilibre partiel ; équilibre général ; États-Unis, zone euro.

TABLE OF CONTENTS

Tables

GAUGING THE IMPACT OF HIGHER CAPITAL AND OIL COSTS ON POTENTIAL OUTPUT

By Boris Cournède[1]

Introduction and summary of main findings

1. The increases in capital costs caused by the financial turmoil and the much higher oil price than earlier in the decade are likely to reduce the productive potential of OECD economies. The cost of borrowing, and therefore the cost of capital, increased markedly during the crisis for all businesses except the best-rated corporations. Although corporate bond yields have been low recently because central banks are keeping short-term rates near zero, over the medium term yields can be expected to stabilise above the levels observed during the credit boom. If investors permanently require more compensation for taking a given risk, this will reduce capital accumulation and imply lower equilibrium output.

2. Similarly, because energy is an important input to the production process in OECD countries, a sustained hike in real energy prices must entail lower equilibrium output. Although the oil price remains far below its 2008 peak, Brent crude still costs about 65%more than before the crisis in real terms in the United States.[2] At a basic level, a higher relative price of energy means greater intensity in the use of other inputs (labour and capital) which are available only in inelastic or limited elasticity supply, implying a fall in productive potential.

3. Using a three-factor production-function framework, the present study provides illustrative estimates of how shocks to capital and energy costs, in three different scenarios, can affect potential output. The main findings are that the effects can be significant but are appraised only with large margins of uncertainty. In the main scenario, where real interest rates are assumed to go back to their average level over the 1991-2001 business cycle and real oil prices stay flat at $80 per barrel, potential output is permanently reduced by around 3½ per cent in the United States and the euro area compared with a situation where real borrowing and energy costs would remain at the average of the levels prevailing when the capital stock in place at the end of 2007 was invested. Against the same baseline, in a hypothetical extreme scenario incorporating higher interest rates to reflect the crowding out of private borrowing by the government, the estimated impacts are 6% reductions in long-term potential output for the United States and the euro area.

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1. Head of the Monetary Policy Unit in the Macro-Economic Policy Division of the OECD Economics Department. This working paper draws on work prepared for the *OECD Economic Outlooks No. 83* to *87.* I am indebted to Ray Barrell, Sebastian Barnes, Sveinbjörn Blondal, Hervé Boulhol, Andrea De Michelis, Jørgen Elmeskov, Peter Hoeller, Peter Jarrett, Vincent Koen, Robert Price, Jean-Luc Schneider, and Lukas Vogel for their useful comments. I also wish to thank Sandra Raymond for excellent secretarial assistance. The opinions expressed in this paper are mine and are not necessarily shared by the OECD or its member countries. Contact details: boris.cournede@oecd.org, +33 1 45 24 90 37.

2. The price of Brent is deflated by the US GDP deflator. The corresponding figure for the euro area is 59%.

4. The next section presents the methodology and the data used for the study. The following section describes the scenarios and presents the simulation results while noting a number of caveats. The final section concludes.

Methodology

5. A production function framework has been used to provide illustrative estimates of the impact of the changes in factor prices on supply. The framework is simple because it looks at the implications of changes in factor prices on steady-state output without taking account of general-equilibrium feedbacks (although some results also hold in a general-equilibrium setting, see below). This choice has been made because it enables the shocks to be calibrated directly on the basis of observed price changes. Nevertheless, the framework used here has the limitation that the real wage is assumed to remain steady in the face of shocks to real energy and capital costs. Related to this, any effects of a wider wedge between firms' real labour costs and workers' real wages on equilibrium unemployment are not taken into account.

6. In the vein of a wide body of empirical research following the seminal work by Rasche and Tatom (1977) and Darby (1982) and recently illustrated by Duval and Vogel (2008), and as in the FRB/US model used by the US Federal Reserve (Brayton and Tinsley, 1996), the present framework uses a standard multi-factor Cobb-Douglas production function

$$Y = \prod_{i=1}^{n} F_i^{\alpha_i} \qquad [1]$$

where the factor shares α_i sum to one. If p_i denotes the price of factor i relative to output, profit maximisation implies that the elasticity of factor i to a change in its relative price is given by:

$$\frac{\Delta Fi / Fi}{\Delta Pi / Pi} = \frac{\partial F_i / \partial p_i}{F_i / p_i} = -\frac{1}{1-\alpha_i} \qquad [2]$$

As a result, steady-state output responds to a change in the relative factor price p_i with the elasticity:

$$\frac{\Delta Y / Y}{\Delta Pi / Pi} = \frac{\partial Y / \partial p_i}{Y / p_i} = -\frac{\alpha_i}{1-\alpha_i} \qquad [3]$$

The impacts of movements in relative factor prices on steady-state output are estimated by integrating the ordinary differential equation (3) so that:

$$\frac{Y_{after}}{Y_{before}} = \prod_{i=1}^{n} \left(\frac{P_{i\,after}}{P_{i\,before}} \right)^{-\frac{\alpha_i}{1-\alpha_i}} \qquad [3]$$

7. While this method evaluates the effect of the oil shock in partial equilibrium, the estimates of the impact of the capital cost shock in fact also obtain under a simple general-equilibrium framework (where only capital is shocked). With iso-elastic utility and Cobb-Douglas production, if the shock to real interest rates is interpreted as a shock to the discount rate, the effect on equilibrium output will be:

$$\frac{Y_{after}}{Y_{before}} = \left(\frac{\delta + \theta_{after}}{\delta + \theta_{before}} \right)^{-\frac{\alpha_i}{1-\alpha_i}} \quad [4]$$

where δ and θ stand for the scrapping and the discount rate.[3]

8. Three factors (*n=3*) enter the production function: labour, business sector capital and oil (including natural gas because its price is closely tied to that of oil). Government capital is not included because the national accounts do not measure its contribution to output. The price of capital p_i which determines production choices is the real user cost of capital, which combines the real interest rate paid by the borrower[4] and depreciation. The average depreciation rate of business capital is calculated in effective terms where different categories of capital are valued according to their efficiency profiles following the "capital services" approach (Schreyer, 2003; Schreyer and Webb, 2006).[5] For oil, the relative factor price is simply the local currency price of Brent as a ratio to the GDP deflator.[6] In the case of an oil shock, the present approach, which assumes constant factor shares, may involve some overestimation of the long-term reduction in the level of potential output. The reason is that, because new capital will be more energy-efficient, the oil and gas share is likely to trend down over time after an oil shock, gradually limiting the impact.

9. Factor prices after the shock have to be compared against a value before the shock. This value is calculated as the average of past real interest rates weighted by the share of each vintage in the total capital stock. As a simplification, the time weights are calculated assuming a smooth path of investment in the past so that the vintage-adjusted real interest rate $\tilde{r}_t$ at the end of year *t* is derived from past values of the real interest rate $r_{t-\tau}$ in years $t-\tau$ and the scrapping rate *s* as in [5]:

$$\tilde{r}_t = \tfrac{1-s}{s} \sum_{\tau=1}^{+\infty} s^{\tau} r_{t-(\tau-1)} \approx \tfrac{1-s^{T+1}}{s} \sum_{\tau=1}^{T} s^{\tau} r_{t-(\tau-1)} \quad [5]$$

where *T* is a cut-off point determined by data availability (15 in the United States, 10 in the euro area).

3. See for instance Wickens (2008), sections 2.4.5.1 and 2.6, for a proof.

4. Business borrowing rates are measured using the yield on BBB corporate bonds. BBB rates provide a good measure of corporate borrowing costs because 70% of corporate borrowing from capital markets is rated BBB or immediately above or below at issuance (Standard and Poor's, 2007). Real rates are derived from nominal bond yields by subtracting the median expectation for ten-year US CPI inflation among professional forecasters surveyed by the Federal Reserve Bank of Philadelphia.

5. While the scrapping rate of capital does not appear explicitly in the services approach as it does in the stock approach, its level can be derived by relating the change in the volume of capital services to the level of investment. See for instance Beffy *et al.* (2006), Footnote 15.

6. International Energy Agency (IEA) indices of real energy prices for end users might be considered as a potential alternative. The local currency price of Brent relative to the GDP deflator has been preferred for three reasons. First, the IEA indices do not cover services. In a framework based on an economy-wide production function, services, which make up significantly more than half of OECD output, have to be taken into account. Second, the economy-wide approach requires considering the price of oil when it enters the economy rather than when it reaches end users because value added in the transport and processing of oil is part of GDP. Third, price indices for end users include excise duties, retail margins and non-deductible value-added tax, three items which are not reckoned in the basic prices at which the oil shares are calculated. As such, price indices for end users are not well suited to the present study.

10. Effects on business sector potential output are translated into corresponding estimates for economy-wide potential output by assuming that the equilibrium output of the government sector is not affected by the shock. This assumption can be regarded as optimistic, and therefore the estimate as conservative, because the funding of government activities ultimately hinges on value added created by businesses, implying that a contraction in business sector output can be expected to extend to the government sector in the long run.

11. The data are taken from various sources. Real interest rates are calculated as bond yields minus long-term inflation expectations. Nominal bond yields on corporate BBB bonds are taken from Thomson Reuters Datastream and inflation expectations come from the surveys of professional forecasters by the Philadelphia Federal Reserve Bank (median value) and the ECB. The yield on BBB-rated corporate bonds serves as proxy for the marginal borrowing cost businesses face when they need external finance to invest. BBB yields have been preferred to data on average bank loan rates which (1) bear only scant relationship with the *marginal* cost of external funds and (2) do not reflect the non-price tightening of bank lending conditions. The surge in corporate bond issuance in 2009 in the euro area and the United States, while bank lending to non-financial businesses slumped, illustrates that, at the margin, firms went to capital markets rather than banks to satisfy their external funding needs. Although imperfect because of liquidity effects, the yields in capital markets nonetheless appear to provide a better proxy for the effective cost of borrowing, including for bank loans, when the shadow price of lending curbs is taken into account.

12. Business sector shares, capital shares and the depreciation rate of the capital stock are calculated based on the O*ECD Economic Outlook No. 84* database. The oil and gas share in production (which can equivalently be seen as the intensity of oil and gas usage in production) is taken from Blanchard and Galí (2007) for the United States and calculated using the *OECD Input-Output Tables* for the euro area. Brent prices are from Datastream and the GDP deflator from the *OECD Economic Outlook No. 87* database.

Results

13. The reference point for the comparison – i.e. "before the shock" – is 2007, the last year of the last cycle of economic expansion. Two scenarios have been considered for capital costs after the shock:

- In Scenario S1, real interest rates are assumed to revert to their average over the previous cycle of 4.9% in the United States over the 1991-2001 period.[7] In the euro area, where comparable data covering the 1991-2001 period are not available, Scenario S1 assumes the same shock to real interest rates as in the United States. In addition to the assumed shock to real borrowing rates, the change in the user cost of capital should also in principle incorporate an assumption for the change in the cost of equity. However, since it would be fair to assume that the cost of equity has

7. Scenario S1 is very closely related though not exactly identical to the assumptions and results reported in Box 4.2 of the *OECD Economic Outlook No. 85* and Box 4.3 of the *OECD Economic Outlook No. 87.* The main difference relates to the way of modelling the starting point for the shock. For the sake of simplicity, these two boxes use a simple average of real interest rates over the 2003-2007 credit boom as their starting point and scale down the estimated impact to take into account the fact that the capital stock did not fully adjust to prevailing factor costs between 2003 and 2007. In the present study, the way of modelling the starting point for the shock has been enhanced by using capital vintage-weighted averages of past real interest rates. Another difference is that the values for borrowing costs used here are slightly different from the corresponding figures in the *OECD Economic Outlook No. 85* because this study measures corporate BBB yields in the United States on a different index which better matches the maturity of the measure of expected inflation in the Philadelphia Fed Survey of Professional Forecasters. It should be noted that these refinements of the methodology do not lead to significant changes in the results, quantitatively or qualitatively.

increased by a similar amount as the cost of borrowed funds, this desirable refinement of the framework would not change the results significantly and has therefore not been incorporated in the calculations.

- Scenario 2 is meant to illustrate a hypothetical extreme adverse case where large government issuance severely crowds out private borrowing. Despite fiscal consolidation plans, the vast funding needs of governments in most OECD countries could have an impact on borrowing rates for firms once desired investment picks up. The prospect of very high public debt-GDP ratios can also push up government bond yields, in turn affecting financing costs for businesses. The transmission from government to corporate bond yields might however be less than one-for-one because corporate spreads can in principle benefit when government debt changes from being risk-free to involving credit risk. Notwithstanding this caveat, in Scenario S2, on top of the rise incorporated in S1, capital costs rise by a further amount equal to the increase in government bond yields between 2007 and 2015 incorporated in the *OECD Economic Outlook No. 87* long-term baseline (OECD, 2010).

Oil prices after the shock are set at the level assumed in the *OECD Economic Outlook No. 87* of $80 per barrel of Brent crude.

Table 1. Illustrative estimates of the impact of the interest rate and oil shocks

	United States		Euro area		
	S1	S2	S1	S2	Unit
Capital					
Vintage-weighted average of real interest rates before the shocl	3.9	3.9	3.0	3.0	%
Assumption for real interest rate after the shock:	4.9	6.2	3.9	5.0	%
Assumed real IR shock	1.0	2.3	1.0	2.0	pp
Scrapping rate	16.4	16.4	14.9	14.9	%
Vintage-weighted real cost of capital before the shock	20.3	20.3	17.9	17.9	%
Assumed real cost of capital after the crisis	21.3	22.6	18.8	19.9	%
Increase in the real cost of capital	4.8	11.3	5.4	11.1	%
Capital share	36.5	36.5	40.3	40.3	%
Reduction in business sector capital stock	7.1	15.5	8.5	16.1	%
Fall in the long-term level of potential business sector GDP	2.7	6.0	3.5	6.8	%
Business sector share	81	81	75	75	%
Reduction in the long-term level of potential GDP	2.2	4.9	2.6	5.2	%
Oil					
Capital vintage-weighted average of past real oil prices	49	49	39	39	$ and €
Assumed future real oil price	80	80	62	62	$ and €
Increase in real oil cost	65	65	59	59	%
Oil and gas share	3.2	3.2	2.1	2.1	%
Fall in the long-term level of potential business sector GDP	1.6	1.6	1.0	1.0	%
Fall in the long-term level of potential GDP	1.3	1.3	0.7	0.7	%
Two shocks combined					
Fall in the long-term level of potential GDP	3.5	6.1	3.4	5.9	%

Notes: Oil prices are reported in domestic currency at 2010 GDP prices.
pp stands for "percentage point", na for "not available."

14. In the main scenario (S1), US real interest rates rise from a capital vintage weighted-average of 3.9% in 2007 to an assumed level of 4.9%, which corresponds to a 5% increase in the real cost of capital. This change reduces the equilibrium level of the capital stock by 7.1% and of GDP by 2.2% in the United States (Table 1). The results for the euro area are similar qualitatively but greater in size because the starting point for real capital costs is lower in absolute terms so that the shock (which has the same size by assumption) produces a larger effect.

15. Scenario S2 corresponds to a much bigger shock on real interest rates which rise by more two percentage points in the euro area and slightly more in the United States (Table 1). In the model, this hit to real interest rates shrinks equilibrium output by about 5% in the United States and the euro area. The estimated effects are comparable despite a lower assumed shock in the euro area because the euro area has a higher capital share and a lower scrapping rate (the latter implying that a similar increase in real interest rates results in a larger relative change in the real cost of capital).

16. The shock to the real oil price is considerably larger than the shock to capital costs (Table 1). However, because the oil and gas share is only a fraction of the capital share, its effects on potential output is smaller (-1.3% in the United States and -0.7% in the euro area). The estimated effect of the oil shock on potential is weaker in the euro area primarily because of its comparatively smaller oil and gas share (Table 1). The elasticities of potential output to the real oil price for the United States and the euro area resulting from the present model are very similar to the estimates obtained by Barrell and Kirby (2008) with a wider macro-econometric model.

17. Some caution is warranted regarding the results relating to the impact of higher energy costs as the oil price shock cannot be interpreted as a pure exogenous negative supply shock. The rise in energy prices should however be seen in the context of globalisation and the re-emergence of China and other developing countries in the world economy. Energy demand from fast-growing developing economies, and the associated increases in oil prices, are the flipside of the contribution these countries make to the growth of global supply, especially in manufacturing. In other words, globalisation increases the productive capacity of the world economy, reduces the prices of manufactured goods (and some tradeable services), and puts upward pressure on commodity prices. Because all effects do not occur at the same time, and in particular the fall in manufactured goods prices appears to have largely occurred before the increases in energy prices, globalisation can now seem to reduce potential output in OECD countries even though its overall contribution is positive. Furthermore, it should be noted that globalisation can hardly be seen as the sole driver of the oil price shock.

18. On the other hand, insofar as oil-importing economies can regard the increase in oil prices can be seen as an unfavourable supply shock, the estimated impacts reported here are conservative. Modelling production with a Cobb-Douglas function implies a high degree of substitutability between energy and other production factors. If capital and energy show a greater degree of complementary, as suggested for instance by Atkeson and Kehoe (1999), an oil price shock will have a greater effect on potential output than what a Cobb-Douglas production function suggests.

Conclusion

19. Taken together, the results from the different scenarios underline that the effects of higher real interest rates and oil prices on potential output and growth are likely to be large even if estimates are surrounded by a wide margin of uncertainty. The impacts on potential output range from 3½ in the main scenario S1 to 6% in a pessimistic scenario where government borrowing pushes up real interest rates.

20. The estimates reported here are only illustrative as they are based on a highly stylised model and they take into account only one among a number of channels through which the crisis can constrain potential growth. In particular, the crisis can also affect the productivity of each unit of capital through its effects on equilibrium employment and total factor productivity (TFP). The very large increase in unemployment provoked by the crisis is likely to have hysteresis effects pushing up structural unemployment (Guichard and Rusticelli, 2010). The consequences of the crisis for TFP are more ambiguous. If investors become more risk averse and reluctant to finance research and development activities, this effect will work to lower TFP. On the other hand, if the crisis frees up resources in finance, real estate and construction that reallocate successfully to more productive sectors, TFP can benefit from this better use of resources. Furthermore, the experience of Nordic countries in the 1990s suggests that policy responses to financial crises in some cases involve structural reforms which are followed by an upward shift in TFP growth (Haugh *et al.*, 2009).

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