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It is now well understood that differences in labour productivity - the value of goods and services that can be produced in an average hour of work - explain many observable economic differences between countries. Evidence shows that highly productive economies outperform their less productive counterparts in terms of per-capita income, population health, subjective wellbeing, and state-capacity (Caselli, 2005; Jones, 2015; Sacks, et al., 2012). For this reason, it is a cause for concern that labour productivity in Scotland - just as in the UK as a whole - is fairly low compared with other advanced economies. It suggests that Scotland could do better, and improve the lives of its citizens by moving up the productivity tables.

In work [published earlier this year](#) by the David Hume Institute (Kelly, et al., 2018), we examined Scotland's productivity performance in an international context. We found that relative to member countries of the OECD - a club of advanced economies - Scotland's labour productivity is only middling: Scotland is more productivity than most poorer OECD countries; but it is less productivity than many of its EU neighbours, including countries such as Finland, Denmark, Belgium and Ireland.

Using data from a variety of sources and novel methods, we were able to show that the productivity gap between Scotland and the OECD's top performers can be attributed to a low capital stock per worker, and low "Total Factor Productivity." The former refers to a country's cumulative investment in machinery, equipment and infrastructure. The latter refers to the efficiency with which an economy combines its productive resources. Our findings suggest that Scotland could raise its productivity by encouraging private and public investment, and tackling possible causes of poor economic management.

Comparing internationally

To understand what drives differences in measured productivity across countries, economists use a method called "development accounting" (Caselli, 2005; 2017). This involves calculating how much of these disparities is attributable to differences in endowments of productive resources, or "factors", commonly assumed to be used by workers: their skills and the physical capital (i.e. machinery, equipment and infrastructure)

with which they work.

In comparing productivity internationally, it is also important to control for the fact the goods and services an economy produces are not necessarily sold at the same price as those it buys. The ratio of these prices determines an economy's "terms of trade" and is particularly important for small and open countries.

If factor endowments and the terms of trade were all that determined an economy's ability to convert labour into consumable output, they would explain all cross-country variation in productivity. In the data, however, they only explain a portion of this variation. What remains is attributed to "Total Factor Productivity" (TFP), which, in short, captures the efficiency with which an economy combines its productive resources to produce output.

Given the appropriately comparable data, development accounting is straightforward. The Penn World Tables (PWT), a source widely used for international comparisons, have collected such information for over four decades. Unfortunately, however, Scotland is not one of the 167 countries for which they have done so.

Scottish PWT data

To decompose Scotland's productivity and compare the results internationally we were therefore required to construct Scottish "PWT data" ourselves. Starting with a standard model of international trade, adding to it the results of recent work on development accounting in open economies by Cuñat & Zymek (2018), and borrowing methodology from the current developers of the PWT (Feenstra, et al., 2015), we were able to do so on the basis of publicly available data for Scotland.

In calculating aggregate productivity we used data from the Scottish Government's [national accounts](#) to construct a measure of GDP identical to that in the PWT, and obtained estimates of annual hours worked from the Scottish Government's [labour productivity statistics](#).

Estimates of capital stocks are not available for Scotland, however Gross Fixed Capital Formation (GFCF) in each year has been recorded since 1998, when Scottish national accounting began. Assuming a capital depreciation rate identical to the UK and calculating the average growth rate of real investment we estimated Scotland's "initial" capital stocks in 1998. This gave us enough information to compute an internationally comparable, annual time series of capital stocks.

In the PWT, an index of workforce skill is provided that relies on estimates of the average

years of schooling obtained in each country's adult population. Since "years of schooling" data are not available for Scotland, we calculated the analogous index by estimating this statistic. To do so, we used EUROSTAT data on the proportion of prime age adults achieving certain International Standard Classification of Education (ISCED) levels and population estimates.

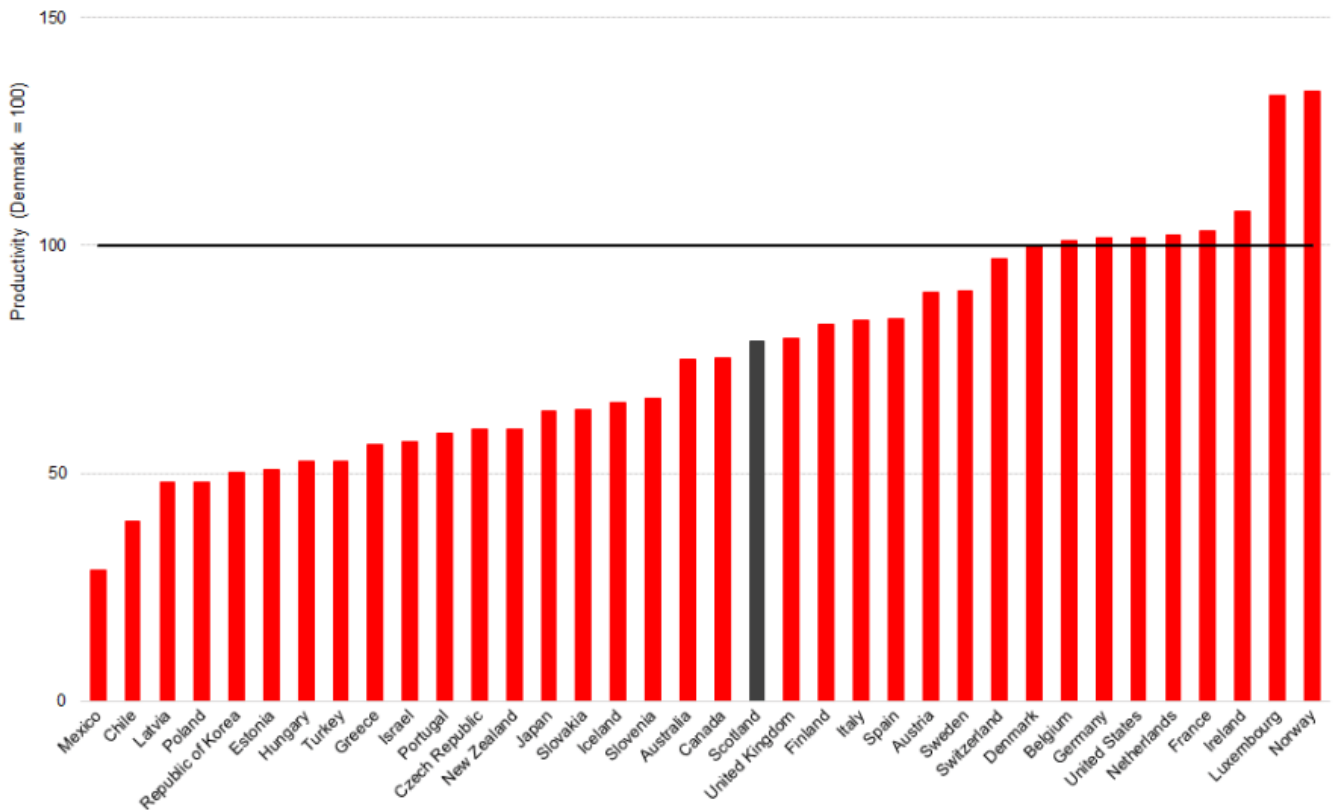
Calculating Scotland's "terms of trade" in a similar manner to the PWT would require detailed information on the quality-adjusted price of Scottish imports and exports. Since this data is not available to us, we use a shortcut based on Cuñat and Zymek (2018) which allows us to construct a measure of the relative price term for Scotland on the basis of Scottish trade data from the [Scottish Input Output Tables](#).

With this new data Scottish TFP can be calculated as the portion of labour productivity that remains unexplained after having accounted for the contribution of workforce skill, capital stock per worker, and terms of trade.

What we found

Chart 1 compares Scottish productivity to that of other OECD economies, a group of rich countries who make up the bulk of the nation's trade. It shows that our calculations place Scotland roughly in the middle of the OECD productivity distribution, with output per hour 20% lower than the reference country Denmark.

Chart 1 - Productivity Across OECD Economies, 2014



Note: Productivity is measured as purchasing-power-adjusted GDP per hour.
Sources: Scottish Government, PWT 9.0, and authors' calculations.

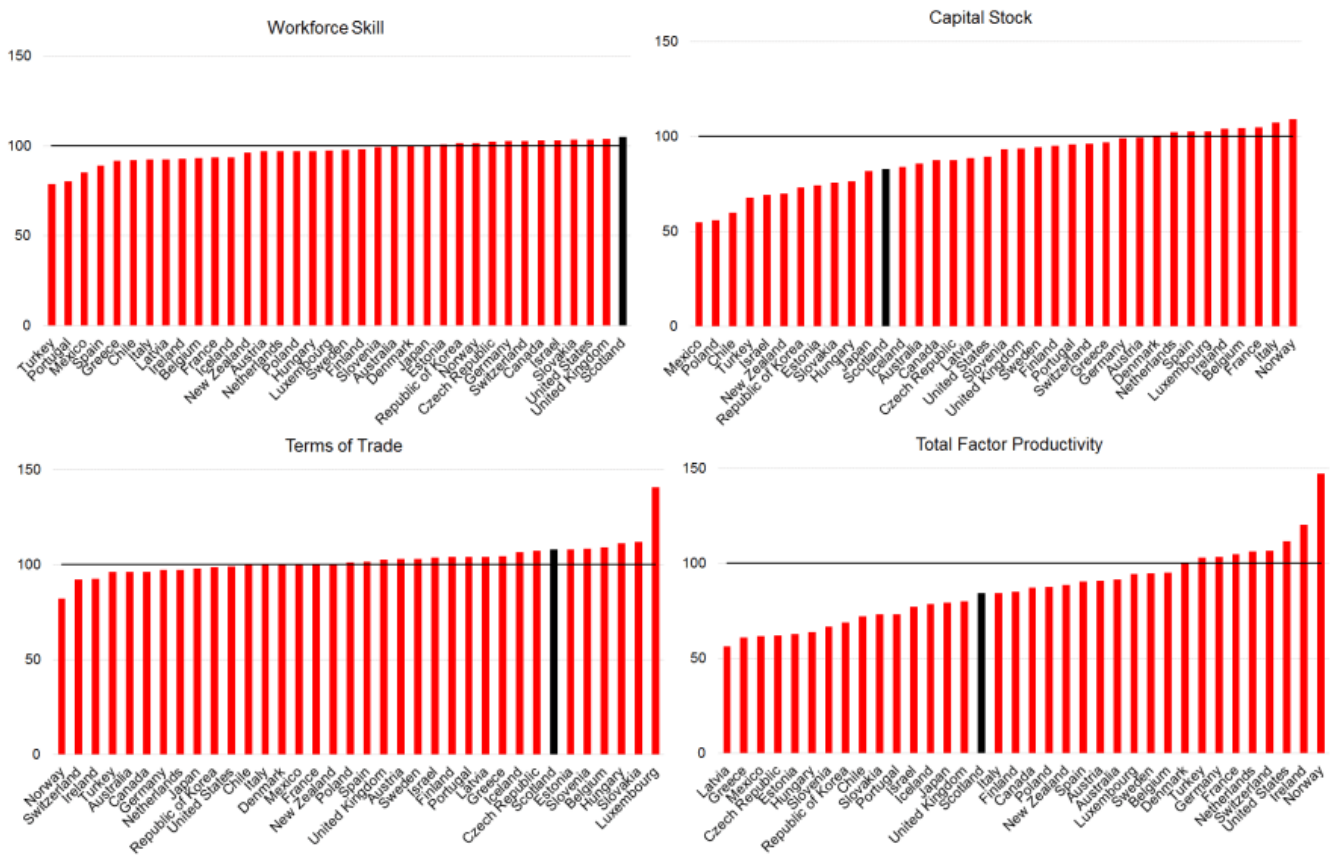
Chart 2 depicts Scotland's standing among OECD economies in 2014, again relative to the base country Denmark, in terms of contributions from workforce skill, capital stock, terms of trade and TFP. The chart shows that Scotland benefits from a relatively high workforce skill (top left panel) and relatively favourable terms of trade (bottom left panel). However, there is overall little variation in either across OECD countries. As such, they do not tell us much about Scotland's overall productivity performance in an OECD context.

Of more relevance is the finding that Scotland falls in the bottom half of the distribution with regards to its capital stock per worker (top right panel) and TFP (bottom right panel). In fact, these relative deficiencies explain all of the gap between Scotland's and Denmark's productivity.

Capital stocks are accumulated through investment in buildings, plants, machinery, and physical infrastructure over time. As we point out in Kelly et al.,(2018), public and private investments has been low in Scotland over the past twenty years compared to its international peers, which has resulted in a relatively low level of capital per worker.

TFP, on the other hand, is less tangible. As a measure of the overall efficiency with which an economy combines its productive resources, it can be affected by a variety of factors. In Kelly et al.,(2018), we use international evidence to suggest that poor quality of management, the prevalence of small and less efficient firms, as well as demographic factors (such as population age) may be possible culprits for Scotland's low TFP.

Chart 2 - Drivers of Productivity Across OECD Economies, 2014



The model and assumptions on which our calculations were based, as well as a more detailed description and discussion of our data sources and methodology, are available in the [Technical Appendix](#) to Kelly et al. (2018). With the information provided in this document, the Scottish "PWT data" can be critically examined, updated and refined as new and richer data sources become available.

What can be done

What are the lessons from our findings for policies aimed at boosting productivity in

Scotland? We show that Scotland could close a large part of its productivity gap with the most productive OECD economies by raising its capital stock per worker. This could be achieved through higher public or private investment, or a combination of both. For example, in Kelly et al. (2018), we highlight that countries like Sweden and Ireland have successfully attracted private investment from abroad through different strategies - Sweden by innovating in the development of its workforce, Ireland by offering financial incentives to investors whilst promoting itself as a place of business to high value, high employment industries.

The causes of low TFP run deeper. In order to diagnose them, and to provide robust remedies, we would require more much detailed data on the allocation of talent, capital and trading opportunities across Scottish firms. This, in turn, would require the compilation and publication of data on economic activity in Scotland at a much more granular level. We hope that the findings presented here highlight the possible rewards from making such data available, and using it to explore the origins of Scottish productivity - an endeavour in which both government and researchers would need to play an equal part.

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