Online Annex. Differences in Output Performance between Europe and the United States during COVID-19

This annex presents the technical details of the results shown in Box 1. The objective of the analysis is to understand what factors explain the difference in output performance recorded in 2020 between the United States and a sample of six European countries.

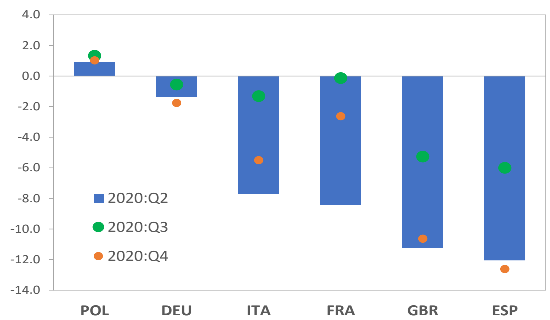
The analysis starts by computing, for each country j, the percent change in its GDP relative to the fourth quarter of 2019:

$$\Delta^L Y_t^j = 100\left(\frac{Y_t^j}{Y_{2019:Q4}^j} - 1\right) \qquad (1)$$

The activity gap with respect to the United States for each European country j in the sample is simply (Figure 1):[1]

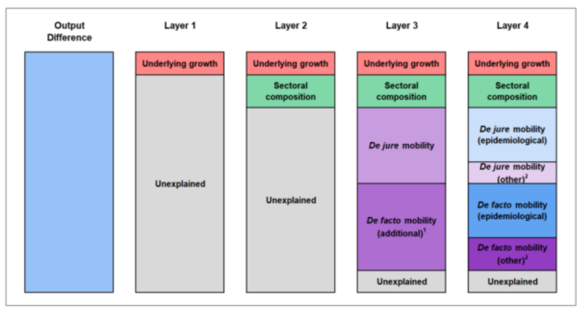
$$\Delta^G Y_t^j = \Delta^L Y_t^{USA} - \Delta^L Y_t^j \qquad (2)$$

Figure 1. Real GDP Change, Relative to US
(Percent, relative to 2019:Q4)



Sources: Haver Analytics; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.

Figure 2. Decomposition Approach



Source: IMF staff calculations.
[1]Purged from the effect of *de jure* mobility.
[2]Purged from the effect of epidemiological variables.

[1] The European countries included in the sample are France, Germany, Italy, Poland, Spain, and the United Kingdom.

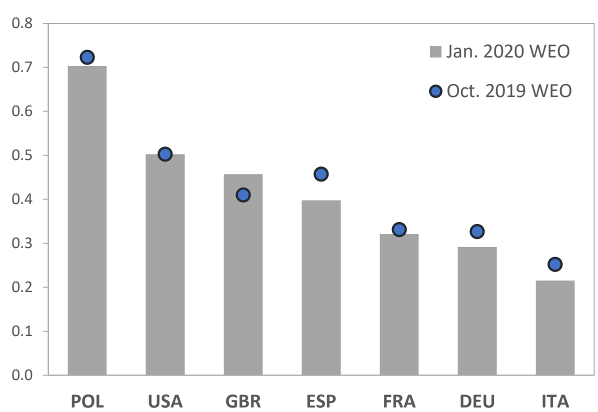
This overall activity gap *vis-à-vis* the United States is then decomposed in layers to assess the contribution of underlying trend growth, the sectoral composition of the economy, the behavioral response to the pandemic (of the authorities and the population), and epidemiological developments (Figure 2).

Layer 1—Underlying trend growth

The first layer quantifies how much of the total activity gap can be attributed to cross-country differences in precrisis aggregate underlying growth momentum. To that end, the analysis uses the average quarterly growth projections at the time of the January 2020 *World Economic Outlook* Update (Figure 3).[2]

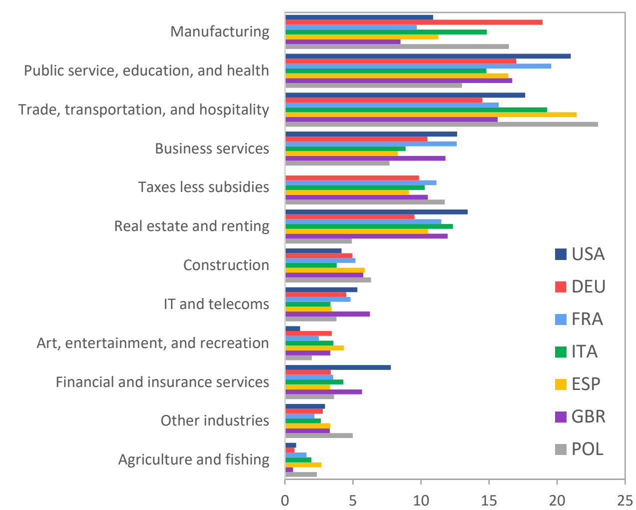
Figure 5 shows that, by the second quarter of 2020, differences in underlying growth momentum accounted for most of the activity gap in Poland—which had a higher growth momentum than the US—and a significant fraction in Germany.

Figure 3. Average Quarterly GDP Growth in 2020 Projected before COVID-19
(Percent)



Sources: Haver Analytics; and IMF staff calculations.
Note: WEO = *World Economic Outlook*. Country abbreviations are International Organization for Standardization country codes.

Figure 4. Sectoral Composition
(Percent of total value added, 2019)



Sources: Haver Analytics; and IMF staff calculations.
Note: IT = information technology. Country abbreviations are International Organization for Standardization country codes.

Layer 2—Sectoral composition of the economy

The next layer in the decomposition aims to account for the significant cross-country differences in the sectoral composition of the economy (Figure 4), as some sectors (for example, contact-intense activities, such as leisure and hospitality) are more affected by social distancing norms than others.

To this end, the activity gap in country j, after adjusting for differences in aggregate trend growth (Layer 1), can be expressed as follows (where ω_i^j denotes the weight of sector i in country j):

$$\Delta^G \tilde{Y}_t^j = \Delta^L \tilde{Y}_t^{USA} - \Delta^L \tilde{Y}_t^j$$

$$= \sum_{i=1}^{N} \omega_i^{USA} \Delta^L \tilde{Y}_{i,t}^{USA} - \sum_{i=1}^{N} \omega_i^j \Delta^L \tilde{Y}_{i,t}^j$$

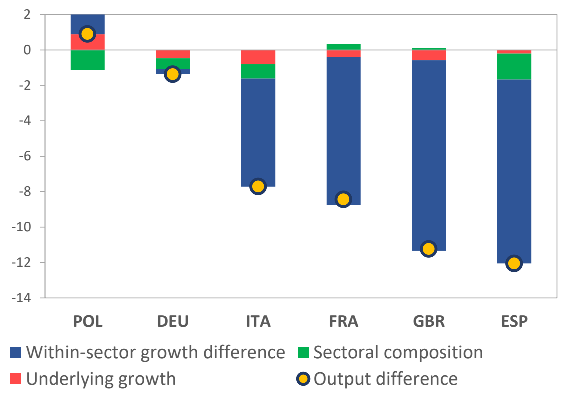
$$= \sum_{i=1}^{N} \left(\omega_i^{USA} - \omega_i^j\right) \Delta^L \tilde{Y}_{i,t}^{USA} + \sum_{i=1}^{N} \omega_i^j \left(\Delta^L \tilde{Y}_{i,t}^{USA} - \Delta^L \tilde{Y}_{i,t}^j\right) \quad (3)$$

The first term at the end of equation (3) corresponds to the contribution of the sectoral composition of the

[2] The cutoff date for this projection vintage was around mid-December 2019. Using projections as of the October 2019 *World Economic Outlook*, when COVID-19 had not even been detected, does not alter the results.

economy to the trend-adjusted activity gap across countries (“sectoral composition” in Figures 5 and 6). The second term, instead, captures the contribution of differences in within-sector growth to the activity gap (denoted “within-sector growth difference” in Figures 5 and 6).

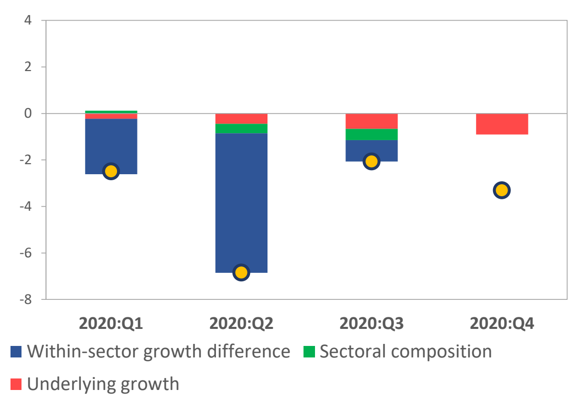
Figure 5. GDP Gap Relative to the US, 2020:Q2—Layer 2
(Percent, relative to 2019:Q4)



Sources: Haver Analytics; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.

Figure 6. GDP Gap Relative to the US, Average—Layer 2

(Percent, relative to 2019:Q4)

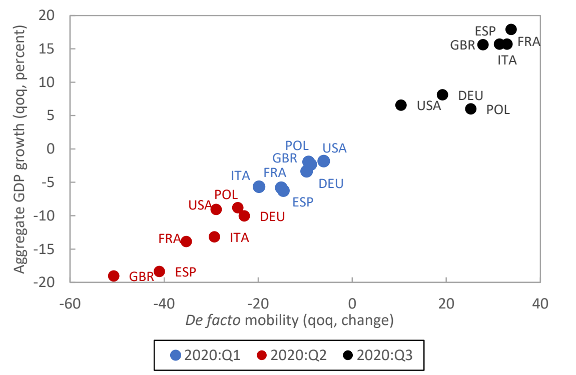


Sources: Haver Analytics; and IMF staff calculations.
Note: The figure shows the decomposition results for the weighted average of the countries in the sample. A full decomposition is not possible for 2020Q4 due to data limitations.

Layer 3—Behavioral response to the pandemic

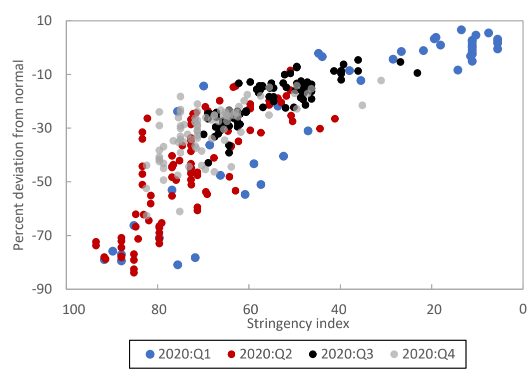
The next layer of the decomposition aims at assessing to what extent the within-sector activity gap (that is, the activity gap stripped from the effects from precrisis trend growth and the sectoral composition of the economy) can be attributed to differences in the behavioral response to the pandemic. There were significant cross-country differences in the observed reduction in mobility (relative to precrisis levels) at any given point in time. These differences are highly correlated with the within-sector activity gaps (Figure 7), across time and across countries. These changes in mobility can reflect the adoption of containment measures by the authorities (for example, lockdowns and curfews) in response to the pandemic as well as voluntary social distancing by the population. These two factors are, however, highly colinear (Figure 8).

Figure 7. Output versus *de Facto* Mobility
(Percent)



Sources: Haver Analytics; Google Community Mobility Report; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.

Figure 8. *De Facto* versus *de Jure* Mobility
(Percent deviation from normal, and stringency index)



Sources: Google Community Mobility Report; Hale and others 2020; and IMF staff calculations.

To assess the contribution of mobility to activity gaps obtained in Layer 2 and to disentangle the contribution of containment measures from self-imposed confinements, the analysis proceeds in two steps. First, *de facto* mobility is regressed on *de jure* mobility in a panel setting at the country level using weekly data:[3]

$$\Delta^L M_t^j = a + b\, \Delta^L R_t^j + e_t^j, \qquad (4)$$

where $\Delta^L M_t^j$ denotes the change in *de facto* mobility in country j (based on Google mobility metrics) in week t relative to its precrisis level,[4] while $\Delta^L R_t^j$ denotes the change in *de jure* mobility (or containment measures, following Oxford Blavatnik's overall stringency index) over the same period. The coefficients are kept constant across countries. The residual from this regression, $\Delta^L(M_t^j | R_t^j)$, denotes "additional" *de facto* mobility—that is, *de facto* mobility beyond what is implied on average by containment measures.[5]

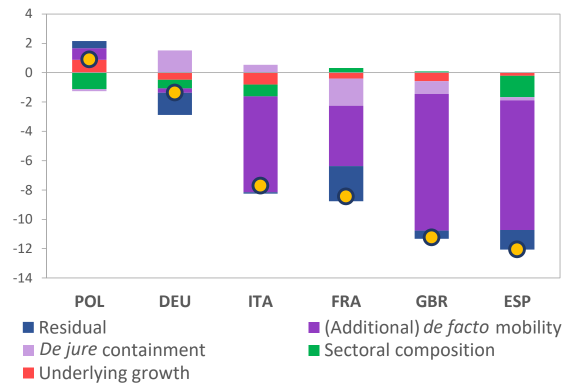
In the second step, sectoral activity gaps are regressed on *de jure* mobility and the "additional" *de facto* mobility in a panel setting at the country-sector level using quarterly data:

$$\Delta^L \tilde{Y}_{i,t}^j = \alpha_i + \tilde{\beta}_i\, \Delta^L(M_t^j | R_t^j) + \tilde{\rho}_i\, \Delta^L R_t^j + \epsilon_{i,t}^j \qquad (5)$$

where $\tilde{\beta}_i$ and $\tilde{\rho}_i$ are sector-specific coefficients.

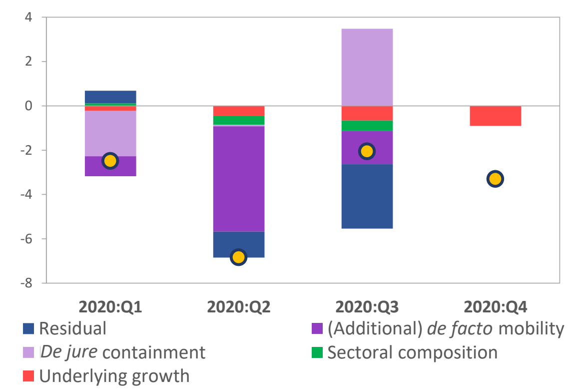
Using the results as of the second quarter of 2020, Figure 9 shows that the residual activity gap at the aggregate level obtained in Layer 2 for some of the European countries can be largely explained by the predicted effect of *de jure* and *de facto* mobility on output at the sectoral level based on equation (5). The residual activity gaps in the second quarter of 2020, once Layer 1-3 results are taken into account, are rather small. While the overall activity gap was much smaller in the third quarter of 2020 than in the second quarter of 2020, the residual gap widened on average, suggesting that the larger relaxation of containment measures in Europe compared to the United States did not lead to a commensurate reaction of activity.

Figure 9. GDP Gap Relative to the US, 2020:Q2—Layer 3
(Percent, relative to 2019:Q4)



Sources: Haver Analytics; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.

Figure 10. GDP Gap Relative to the US, Average—Layer 3
(Percent, relative to 2019:Q4)



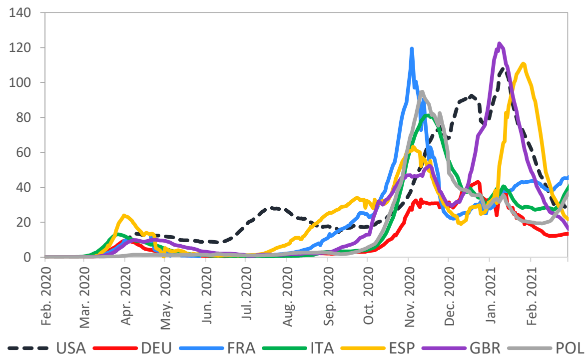
Sources: Haver Analytics; and IMF staff calculations.
Note: The figure shows the decomposition results for the weighted average of the countries in the sample. A full decomposition is not possible for 2020:Q4 due to data limitations.

[3] In a robustness exercise, we account for the non-linear relationship between *de jure* and *de facto* mobility, which slightly increases the weight of containment measures in the decomposition.
[4] The mobility data is taken from Google and realigned in index form, where 100 corresponds to the pre-COVID-19 baseline (the median value for each day of the week over the period January 3 – February 6, 2020) and with values below 100 indicating the percentage mobility below normal. The *de facto* mobility metric used corresponds to the average of retail, workplace, and transport mobility metrics from Google.
[5] The underlying assumption is that—in a given week—containment measures cause the changes in actual mobility, and not the other way around. This assumption is used to address the multicollinearity of explanatory variables.

Layer 4—Epidemiological developments

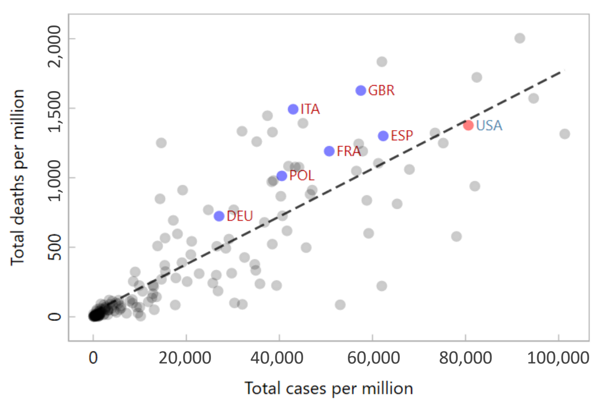
The timing and intensity of the pandemic (as captured by the weekly average of new cases) was heterogenous across countries (Figure 11). Moreover, the spread of the pandemic was often associated with more severe outcomes in European countries. This is reflected, for instance, in higher hospitalization and fatality rates for a given number of infections (Figure 12).

Figure 11. New Daily COVID-19 Infections
(Cases per 100,000)



Sources: Haver Analytics; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.

Figure 12. Intensity of COVID-19 Pandemic
(Cumulative fatalities and infections per million)



Sources: Our World in Data; and IMF staff calculations.
Note: Data as of January 31, 2021.

The next layer in the decomposition aims to assess to what extent the larger mobility contraction in Europe—especially self-enforced—can be explained by cross-country differences in epidemiological developments.[6] Importantly, this layer of the decomposition does not affect the magnitude of residual shown in Layer 3; it only decomposes the contribution of the mobility factors.[7] To this end, the number of new fatalities is first regressed on the number of new COVID-19 cases (both expressed as a share of the population) using a panel at the country level and using weekly data:

$$FR_t^j = c + d\, IR_t^j + e_t^j, \qquad (6)$$

where FR_t^j and IR_t^j denote the weekly average of daily deaths and daily infection cases per million inhabitants in country j and week t.[8] The number of daily cases is lagged one week to take into account the delay between when a case is diagnosed and when a severe manifestation develops.[9] The residual from this regression, $FR_t^j|IR_t^j$, denotes "additional" fatalities—that is, the extent of fatalities beyond what can be attributed, on average, to the number of infections.

Second, the two mobility indictors used in Layer 3 (*de jure* mobility and "additional" *de facto* mobility) are, alternatively, regressed on infection rates and "additional" fatality rates:

$$\Delta^L R_t^j = \alpha^R + \gamma^R\, \Delta^L\left(FR_t^j|IR_t^j\right) + \delta^R\, IR_t^j + \epsilon_t^j$$
$$\Delta^L\left(M_t^j|R_t^j\right) = \alpha^{M|R} + \gamma^{M|R}\, \Delta^L\left(FR_t^j|IR_t^j\right) + \delta^{M|R}\, IR_t^j + \epsilon_t^j \qquad (7)$$

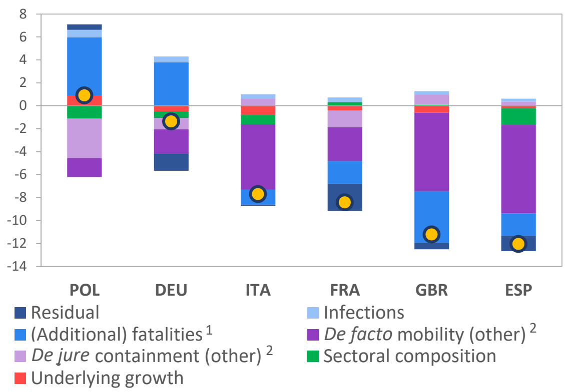
[6] While there are likely endogenous dynamics between mobility and epidemiological developments over time, the analysis assumes that mobility measures can respond to contemporaneous epidemiological developments within a given week (not the other way around), but does not impose any restrictions on their relation across different weeks.

[7] In a robustness exercise, epidemiological factors are also allowed to affect output directly (and not only via the two mobility measures). The results remain largely unaffected, suggesting that most of the effect of epidemiological factors is captured through the mobility channel.

[8] The data for infections (daily cases and deaths per million) are obtained from Our World in Data.

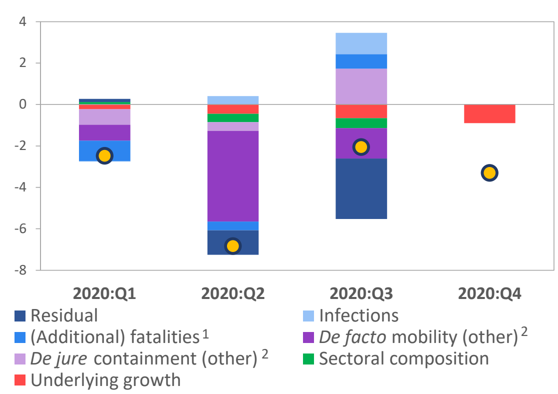
[9] The explanatory power of daily cases increases significantly when a one-week lag is considered. Considering a longer lag did not affect the result significantly.

Figure 13. GDP Gap Relative to the US, 2020:Q2—Layer 4
(Percent, relative to 2019:Q4)



Sources: Haver Analytics; Our World in Data; and IMF staff calculations.
Note: Country abbreviations are International Organization for Standardization country codes.
[1]Purged from the effect of infections.
[2]Purged from the effect of both infections and fatalities.

Figure 14. GDP Gap Relative to the US, Average—Layer 4
(Percent, relative to 2019:Q4)



Sources: Haver Analytics; Our World in Data; and IMF staff calculations.
Note: The figure shows the decomposition results for the weighted average of the countries in the sample. A full decomposition is not possible for 2020:Q4 due to data limitations.
[1]Purged from the effect of infections.
[2]Purged from the effect of both infections and fatalities.

Figure 13 shows the decomposition of the contribution of each mobility variable to the activity gap up to the second quarter of 2020 into what can be explained by epidemiological developments (labeled "infections" and "additional fatalities") and what cannot (labeled "*de facto* mobility, other" and "*de jure* mobility, other"). The results suggest that a significant fraction of the activity gap registered by the second quarter of 2020 in France, Italy, Spain, and the UK can be attributed to the effect that the severity of the pandemic had on mobility. The average activity gap between Europe and the US declines by the third quarter of 2020, but the unexplained residual increases somewhat. This reflects a stronger rebound of mobility during the first re-opening phase in Europe, which is not matched by a commensurate output performance (Figure 14).

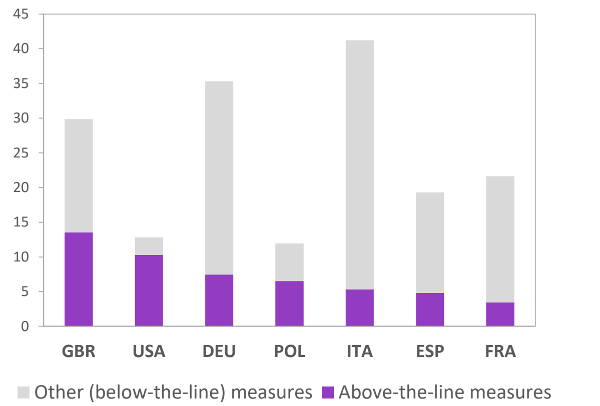
Concluding remarks

Accounting for differences in underlying growth, the sectoral composition of the economy, and the drop in *de jure* and *de facto* mobility explains the bulk of the activity gap between the United States and some of the large European economies in 2020. To begin with, the gap is fairly small in some countries (for example, Germany and Poland). For countries with larger activity gaps, stricter voluntary confinements—beyond what can be attributed to sterner containment measures—explain most of it. A significant part of this mobility gap, in turn, reflects that the pandemic was more severe in Europe (reflected in a higher number of hospitalizations and fatalities for a given number of infections).

The residual or unexplained activity gap—after accounting for underlying growth, the sectoral composition of the economy, and the drop in *de jure* and *de facto* mobility—could reflect, among other factors, differences in macroeconomic policies. The set of spending and revenue measures adopted in the United States in 2020 was indeed generally larger than in Europe (Figure 15).[10] However, fiscal packages in Europe also included sizable support through below-the-line measures and state guarantees; and the overall response was also largely effective in preserving income and firms' liquidity (Figure 16) Fiscal policy lags would also imply that any differentiated effect across countries would only become apparent beyond 2020.

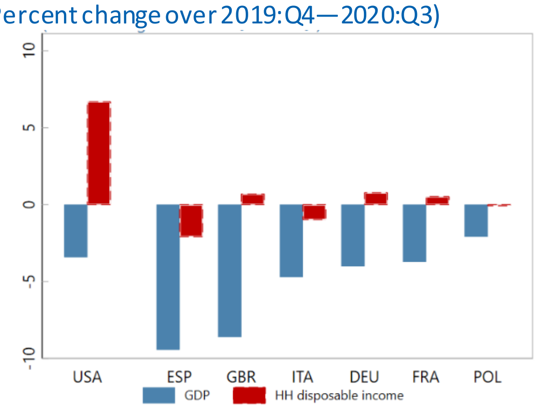
[10] This excludes the recent US fiscal support measures introduced in the Consolidated Appropriations Act of 2021 and the American Rescue Plan Act of 2021, which had no impact in 2020.

Figure 15. 2020 Fiscal Response to COVID-19
(Percent of GDP)



Sources: Fiscal Monitor database of COVID-19 measures (as of Feb 5, 2021); and IMF staff calculations.
Note: Only above-the-line measures to be executed in 2020 are included. Country abbreviations are International Organization for Standardization country codes.

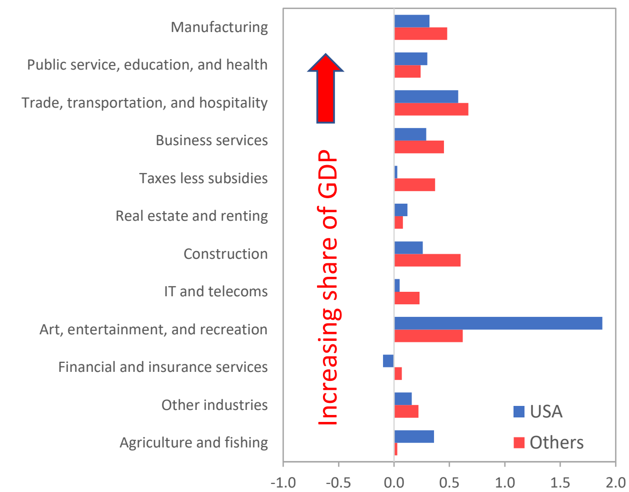
Figure 16. Output and Households' Disposable Income
(Percent change over 2019:Q4—2020:Q3)



Sources: Haver Analytics; and IMF staff calculations.
Note: HH = household. Country abbreviations are International Organization for Standardization country codes.

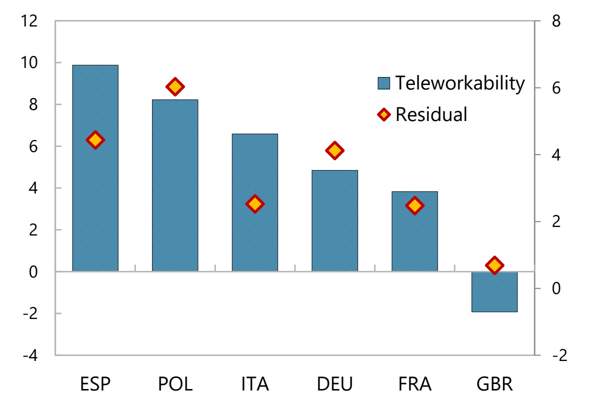
The residual gap can also reflect, among other things, a better adaptability of the US economy to operate under reduced mobility. For instance, allowing the coefficients in equation (5) to vary across countries, suggests that the elasticity between output and mobility is smaller in the United States than in Europe (implying a lower drop in output for a given reduction in mobility) in sectors that are relatively large (Figure 17). This could reflect that the US economy is more flexible and could adapt better to operate in a context of reduced mobility. One aspect that could have facilitated its ability to preserve economic activity under restrained activity is its high ability to telework (Figure 18).

Figure 17. Elasticity of Output to *de Facto* Mobility
(Percent)



Sources: IMF staff calculations.
Note: IT = information technology.

Figure 18. Residual Activity Gap in 2020:Q3 and Teleworkability
(Difference in share of teleworkable jobs with respect to the US, lhs; Layer 3 activity gap residual, percent, rhs)



Sources: Dingel and Neiman 2020; and IMF staff calculations.
Note: lhs = left-hand scale; rhs = right-hand scale. Country abbreviations are International Organization for Standardization country codes.

References

Dingel, Jonathan I., and Brent Neiman. 2020. "How many jobs can be done at home?" *Journal of Public Economics*, 189.

Hale, Thomas, Noam Angrist, Emily Cameron-Blake, Laura Hallas, Beatriz Kira, Saptarshi Majumdar, Anna Petherick, Toby Phillips, Helen Tatlow, and Samuel Webster. 2020. Oxford COVID-19 Government Response Tracker, Blavatnik School of Government.