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Increased pharmaceutical exports have both aggregate and distributional effects

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We use the Disaggregated Economic Accounts (DEA) model, developed by Andersen et al. (2023), to study the consequences of an increase in Danish pharmaceuticals exports. The model predicts that consumption and output increase following an increase in pharmaceutical export, but that the increase in output is temporary and vanishes when wages adjust. Although aggregate output is unchanged in the longer run, activity shifts between municipalities and industries. We compare these effects to the effects of a similar increase in general manufacturing exports.

An increase in exports shifts activity between municipalities but increase consumption across all of Denmark

An increase in pharmaceutical exports mainly shifts activity between municipalities around the Copenhagen area. Conversely, if general manufacturing exports increase, activity shifts between municipalities across all of Denmark. In both cases, activity shifts because higher demand leads to a general wage increase. This enhances Danish consumers' purchasing power abroad and thereby increases their consumption. This is a medium-run effect of the export shock.

The geographical distribution of an export shock influences its aggregate effect

In contrast to pharmaceutical exports, general manufacturing exports are typically produced in rural areas with lower consumer import shares. In the short run, this results in a slightly greater GDP effect from a manufacturing export shock compared to a pharmaceutical one in the DEA model. This is due to a larger share of the income gains from the shock being spent domestically. However, the overall aggregate effects of the two shocks are quite similar.

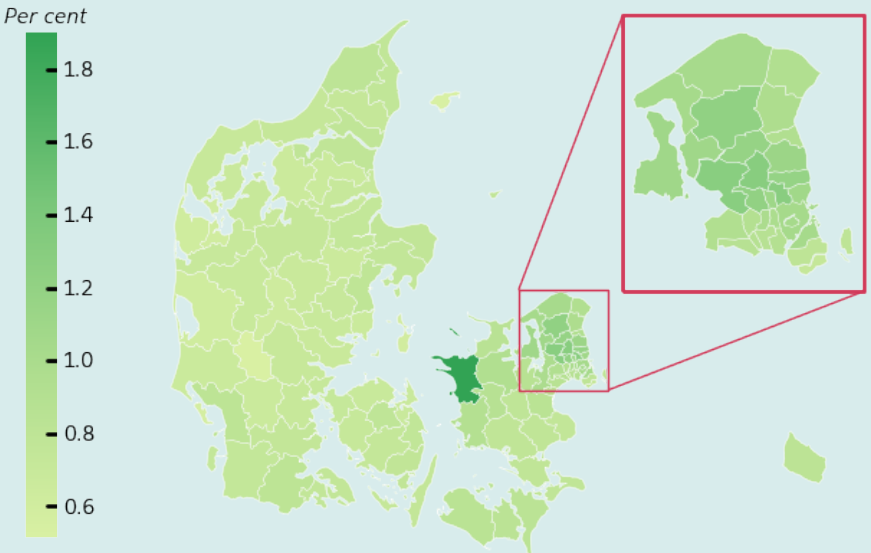
Pharmaceutical export gains are more geographically concentrated than general manufacturing export gains

Pharmaceutical exports are produced in fewer municipalities than manufacturing exports, which leads to more geographically clustered output and consumption gains. This pattern is reinforced by consumer spending patterns, since employees in the pharmaceutical sector tend to spend less in rural areas compared to those in manufacturing. Thus, the indirect export gains will be distributed less broadly across Denmark. This is a short-run effect of the export shock.

Why is this important?

This memo contributes to a better understanding of some of the previously unexamined consequences of shocks to pharmaceutical exports, showing that aggregate consequences potentially mask significant geographical heterogeneity. The memo also contributes to a better understanding of the GDP multiplier following different kinds of export shocks, taking into account that the indirect effects of a shock depend on which consumers are affected by the shock. As pharmaceutical exports become more important for the Danish economy, understanding the consequences of shocks to Danish pharmaceutical companies is becoming more important. This memo provides relevant insights for Danmarks Nationalbank's assessment of the current and future economic development in Denmark and corresponding economic policy recommendations.

Main chart: Consumption increases across all of Denmark following an increase in Danish pharmaceutical exports, but the consumption gains are largest in Northern Zealand and in Kalundborg



Note: The percentage change in real consumption is measured as the real consumption in equilibrium for each municipality in the version of the DEA model without nominal rigidities, relative to the baseline real consumption in each municipality. As a result, the map shows the medium run impact of a pharmaceutical export shock.
Source: Own calculations based on the DEA model.

Keywords

Danish economy | Danish foreign trade | Economic activity | Models

01
Introduction

In recent years, the global growth of Danish pharmaceutical companies has significantly increased pharmaceutical industry exports from Denmark. Exports from the pharmaceutical industry increased by approximately 58 per cent in current prices from 2018 to 2022. In comparison manufacturing exports excluding pharmaceuticals increased around 37 per cent in the same period.[1] As a result, the pharmaceutical industry is increasingly important for the Danish economy and a better understanding of the aggregate and regional effects of shocks to the pharmaceutical industry can therefore be relevant input for future economic policy decisions.[2] This includes the effects on local labour market.

In this memo we analyse the implications of high growth in pharmaceutical exports compared to general manufacturing exports using the Disaggregated Economic Acounts model (DEA), developed by Andersen et al. (2023). The DEA model is an innovative macroeconomic model of the Danish economy that considers the differences observed in the data on how small groups of consumers, and producers (classified by industry and region), the government, and the rest of the world are connected through the flow of funds. In general, this heterogeneity has not been taken into account by existing macro models of the Danish economy.[3]

Specifically, we use the DEA model to study the importance of pharmaceutical exports by comparing an export demand shock to the pharmaceutical industry to an export demand shock to manufacturing exports in general.[4] Essentially, we ask how the effects on the Danish economy, as represented in the DEA model, differ depending on whether the foreign demand increases for Danish pharmaceuticals or more generally for Danish manufacturing.[5]

The large heterogeneity in the DEA model enables us to compare the distributional consequences of the two types of export shocks across industries and geographical areas. Additionally, the model provides new insights into the indirect and aggregate effects of different types of export shocks to the Danish economy. These insights complement the knowledge gained from other macroeconomic models of the Danish economy. To illustrate this, we compare the aggregate results from the DEA model to those from a similar shock in the ADAM model.

[1] Based on data from MONA's database and Statista (2024).
[2] Since this memo analyses the effects of an increase in pharmaceutical exports produced within Denmark, its insights may not directly apply to the most recent development, where the pharma industry is a main driver of the increase in merchanting and processing (M&P). Merchanting and processing are defined as activities of Danish firms abroad in which they buy and sell products abroad or transform inputs from other firms into final goods and sell these goods abroad. In both cases the goods never cross the Danish border but are bought, produced and sold abroad.
[3] See chapter 2 for more details, or Andersen et al. (2023).
[4] The recent large increase in exports of the pharmaceutical industry in Denmark could also be interpreted as a shock to productivity rather than demand. In this memo we focus on the latter and leave the analysis of a technology shock for future analytical work. However, an increase in productivity does not involve the same trade-offs since overall output both in the long and short run will increase when growth increases permanently.
[5] The pharmaceutical industry is part of the general manufacturing industry, and we therefore compare an increase in demand for pharmaceutical exports to a general increase in manufacturing, including pharmaceutical exports.

The purpose of the memo is twofold: to apply the DEA model to increase our understanding of the recent growth in Danish pharmaceutical exports, and to highlight the new analytical opportunities that the DEA model presents.

02

Characteristics of the disaggregated economic accounts

The innovation of the DEA model and its underlying data measurement framework lies in its ability to capture the heterogeneity in how small groups of consumers, producers, the government, and the rest of the world are interconnected through the flow of funds. Approaches that only consider changes in aggregate consumption, for example, can mask a high degree of heterogeneity in consumption patterns across households.

In their work, Andersen et al. (2023) contribute to a better understanding of the significance of this heterogeneity in two ways. First, they provide a method for measuring the flow of funds defined by the national accounts, allowing for greater real-world complexity to be preserved. Second, they calibrate a model to reflect the measured heterogeneity. In the following, we first describe the measurement framework and the patterns observed from the data, and then describe the macroeconomic model calibrated using this data.

Underlying data reveals significant heterogeneity of flow of funds

In essence, the DEA measurement framework organises data in such a way that the flow of funds between different economic agents (called cells) can be observed. In this framework, each cell is characterised by both the industry of employment or production, as well as by the municipality of residence or establishment, respectively. Box 1 provides a more detailed summary of the measurement framework. [6]

The main insights derived from the data using the DEA measurement framework can be summarised by a triangular trade pattern that captures the flow of funds between urban and rural areas and the rest of the world. Andersen et al. (2023) characterise this triangular trade pattern based on four main observations. First, they observe that consumers tend to spend more of their income in more urban areas than where they live. Second, consumers living in urban areas spend more of their income abroad. In parallel, despite providing more transfers to rural areas, the government spends a larger share of its income in urban areas, where it predominantly produces and allocates funds. Finally, industries in rural areas have a larger export share than urban areas that produce goods and services for domestic consumption. This triangular trade pattern of flow of funds between rural areas, urban areas and the rest of the world is illustrated in chart 1.

The DEA model is a two-period general equilibrium model calibrated to match the observations from the DEA measurement framework. It provides a consistent method for analysing the implications of the connections between groups observed in the data. This model allows for the analysis of various economic shocks, taking into account the observed heterogeneity in the data. As a result, the DEA model provides the necessary framework for studying the equilibria that emerge under different scenarios. It can be used to study either the medium-run or short-run implications of a shock, depending on whether wages are assumed

[6] For further details, see Andersen et al. (2023).

to be fully flexible or sticky. Table A in box 2 summarises the characteristics of the DEA model and compares them to the macroeconomic model ADAM.[7]

BOX 1

Measuring disaggregated flow of funds: The DEA measurement framework

The DEA measurement framework provides a consistent way of disaggregating the flows that constitute the national accounts into flows of funds between groups of consumers, producers, the government, and the rest of the world. Andersen et al. (2023) measure a national account unit for each cell, based on the flows of funds between different cells, in such a way that in the aggregate they match the Danish national accounts and all national accounting identities are fulfilled. This disaggregation of the national accounts allows for the measurement of how all cells are connected through, for example, trade in intermediates (producer-to-producer cells), private consumption (consumer-to-producer cells) and labour compensation flows (producer-to-consumer cells).[1] These flows are measured using different data sources, including microdata from Statistics Denmark, Danske Bank and CrediWire.[2]

In the DEA measurement framework, consumer and producer cells are defined by their geographical location (municipality) and their industry of production or occupation.[3] When the DEA model is calibrated with this data, each combination of municipality and industry of employment or production constitutes a cell that serves as a representative agent in the DEA model. Since the DEA measurement framework defines 27 producer industries and Denmark consists of 98 municipalities, the DEA model consists of around 2,700 representative consumers and around 2,700 representative producers.[4] In other words, the DEA measurement framework provides an input-output matrix for every municipality in Denmark, whereas the national account (and thereby also ADAM) only provides this information for the entire economy.

The measurement of inflows and outflows for each cell means that each cell has a unique composition of flows and trading partners. Importantly, this also means that the import share of consumption differs across cells, resulting in a triangular trade pattern. For example, a consumer employed in manufacturing but residing near Copenhagen will have a different consumption basket than a consumer also employed in manufacturing but living in a rural area. Similarly, producers within the same industry may use different inputs depending on their location, as inputs also vary by location.

[1] They disaggregate 36 flows of the national accounts for each cell; see Table I in Andersen et al. (2023).
[2] See table A.XV in Andersen et al. (2023) for an overview of the data sources.
[3] For producers, geographical location is defined by the municipality where the production is located. For consumer cells, location is determined by the consumers' municipality of residence.
[4] Within each municipality, consumers can, in addition to the 27 output-producing industries, also belong to non-output-producing cells, such as those representing pensioners or the unemployed. See table A.1 in Andersen et al. (2023) for an overview of industry classifications.

The DEA model complements existing models

Specifically, the characteristics of the DEA model imply that the GDP multiplier of a shock depends on which cell is initially affected by the shock. In the model, the triangular trade pattern observed in the data results in a larger multiplier of

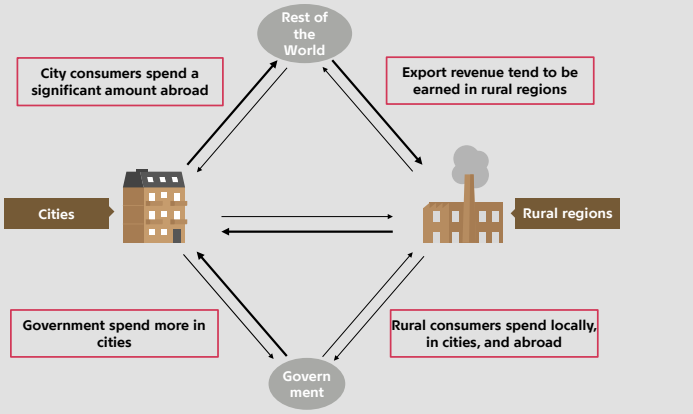
[7] ADAM is used by the Ministry of Finance for outlooks used by other institutions for policy analysis; see Statistics Denmark (2013). We compare the aggregate implications identified by the DEA model to ADAM, since ADAM includes more heterogeneity in terms of producer industries and a detailed input-output system for the economy compared to Danmarks Nationalbank's own structural econometric model, MONA.

shocks that initially affect rural areas, where consumers on average spend less of their consumption on imports. The indirect activity effects of a shock therefore depend on how the shock is distributed across cells. This complements insights from existing models of the Danish economy, which do not account for the same degree of heterogeneity in household consumption patterns.

CHART 1

The triangular trade pattern

The chart illustrates a significant flow of funds from rural regions to urban areas driven by the consumption of rural consumers. Government spending also disproportionally flows towards urban areas. At the same time, there is a flow of funds from urban consumers to the rest of the world, as they have a larger import share. On the other hand, funds from the rest of the world generally flow towards rural areas where exporting industries are located.



Source: Andersen et al. (2023) and own illustrations.

In comparison to ADAM, the DEA model also provides knowledge of the geographical distribution of economic consequences, since the DEA cells include a geographical dimension. This allows the model to give information on how local labour markets are affected by a shock that cannot be studied using a standard macroeconomic model such as ADAM.

It is important to note that the DEA model should be seen as a complement to other models of the Danish economy, such as DSGE models or SEMs. The DEA model provides new insights into the impact of economic shocks on the Danish economy, but does not account for all effects of such shocks.

Notably, the DEA model does not include capital accumulation, as shown in table A.[8] Consequently, it does not account for the effects of capital adjustments through investment. As a result, the DEA model underestimates the aggregate impact of an economic shock compared to models that include investments. The extent of this underestimation is unclear, as it depends on how different cells in the model adjust capital following the shock. This heterogeneity also determines how the inclusion of capital adjustments would impact the distributional consequences of an economic shock.

[8] Inclusion of capital in the DEA measurement framework and model is under development in collaboration with Danmarks Nationalbank.

In summary, this highlights the need to use the DEA model as a complement to other models. As with any model, effects derived from the DEA model should be interpreted within the model's framework, taking into account its advantages and limitations. In the following chapters, the described effects of the export shocks should therefore not be interpreted as facts but as the model's predictions.

BOX 2

Table A:
Comparison of model characteristics of the DEA and ADAM models

	DEA	ADAM
Model class	General equilibrium	Structural econometric model
Model properties	Neoclassical but with New Keynesian properties in the short run	Neoclassical with Keynesian properties in the short run
Producer heterogeneity	27 Industries X 98 Municipalities	12 Industries
Consumer heterogeneity	31 Industries[1] X 98 Municipalities	Representative consumer
Geographical dimension	98 Municipalities	No
Investments	No	Yes
Dynamic path towards long run equilibrium	No	Yes
Time horizons included in model	Short and medium run equilibria	All time horizons towards long run equilibirum
Characteristics of short-run equilibrium	Wages are assumed to be sticky[2]	1-3 year effect
Characteristics of medium-run equilibrium	All prices have adjusted	Dynamic
Small open economy with currency peg	Yes	Yes
Consistent with NA identities	Yes, minus investment	Yes
Baseline year	2018/2019[3]	2023[4]

Note: Neoclassical properties in DEA and ADAM means that producers and consumers maximise profits and utility under their budget constraints, and economic development in the long run is determined by supply. For more detailed information about the two models, see Andersen et al. (2023) and Statistics Denmark (2013).
Source: Andersen et al. (2023) and Statistics Denmark (2013).

[1]The four additional consumer categories, compared to producers, account for consumers who belong to non-producing groups: the unemployed, students, pensioners and those out of the workforce.
[2]This corresponds to the DEA model's short-run New Keynesian properties.
[3]Since the baseline year for the DEA model is 2018/2019, it cannot be used directly for outlooks, for example because the export of pharmaceuticals has increased massively since then. However, the model is still useful for analysis of the short-run implications of an economic shock, provided the shock size is calibrated to match the Danish economy in 2018/2019. Using the model in 2024 also assumes that the connections between cells (e.g. the triangular trade pattern) still apply.
[4] ADAM's baseline is non-stationary, i.e., it incorporates growth. See Statistics Denmark (2013) for more details. The first baseline year is 2023.

03
Aggregate implications of a demand shock

From 2018 to 2022, pharmaceutical exports increased by 58 per cent, while manufacturing exports excluding pharmaceuticals grew by 37 per cent. Pharmaceutical exports in 2022 were approximately DKK 21 billion higher than they would have been if they had grown at the same rate as manufacturing exports from 2018 to 2022, maintaining a constant ratio between the two. To analyse the implications of this disparity in export growth, we use the DEA model to compare the consequences of a DKK 21 billion increase in general manufacturing exports versus an equivalent increase in pharmaceutical exports.

The pharmaceutical industry is not included in the DEA model as a separate industry but is part of the general manufacturing industry.[9] To study the impact of an increase in pharmaceutical exports we therefore identify the cells in which pharmaceutical industries are the most important producers among manufacturing cells. We do this by identifying municipalities where the manufacturing industry is dominated by pharmaceutical production.[10] Shocking these cells in the DEA model therefore closely corresponds to a shock to the pharmaceutical industry.

We calibrate the shock to each cell so that the size of the shock equals the export share of each cell considering that the total shock amounts to DKK 21 billion.[11] The shock corresponds to approximately ¾ per cent of GDP.

A demand shock increases aggregate GDP in the short run, but the increase is not permanent

In the DEA model an increase in the foreign demand for either the pharmaceutical industry or the manufacturing industry in general increases the demand for domestically produced goods. This causes producers to demand more workers to increase their production. This is possible since employment can temporarily exceed its structural level because wages and prices do not fully adjust in the short run.

In the medium run, wages and prices will increase because of the demand shock, and employment will therefore return to its structural level and the aggregate effect on GPD will diminish. In the medium run, GDP is determined by the supply of labour and capital, and the supply of labour does not change following an export demand shock.12 This corresponds to the mechanisms in ADAM, although in ADAM, capital adjusts too, in contrast to the DEA model where capital is held constant. The aggregate consequence of this difference is discussed below.

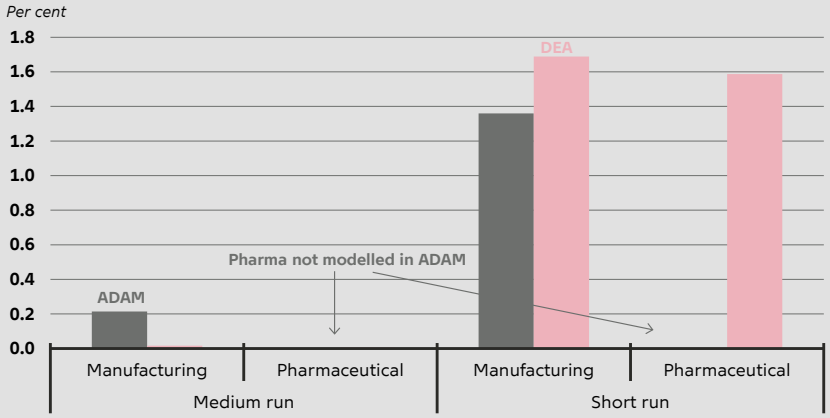
[9] This is also the case for ADAM.
[10] Since the input of intermediates from other producers and the composition of consumption vary between industries and municipalities, this approach allows for differences in trade of intermediates and consumption responses compared to general manufacturing.
[11] This does not necessarily reflect the most recent development in production in the pharmaceutical industry which to a large extent has been driven by M&P activities outside of Denmark.
[12] In the DEA model the labour force can increase following a demand shock since the supply of foreign labour can adjust. However, the elasticities of both cross-border labour demand and supply are relatively small, meaning that changes in labour supply and output are negligible in the medium run; see Andersen et al. (2023).

Chart 2 shows both the short run and medium run impact on aggregate GDP of different types of export demand shocks according to both the DEA and ADAM model. The chart illustrates that even though the models differ substantially the effects are comparable. In the medium run in both models, the impact on aggregate GDP is zero or close to zero. Aggregate GDP in the ADAM model increases slightly because higher wages decrease the relative price of capital and thus lead to an increase in capital in the medium run equilibrium.

CHART 2

The impact on aggregate GDP is within the same order of magnitude in DEA and ADAM

Change in GDP compared to baseline.



Note: The chart shows the percentage change of GDP compared to the baseline in DEA and ADAM. In the DEA model, the percentage change is measured as the impact on GDP in equilibrium from the model with fully flexible wages (medium run) and sticky wages (short run) compared to the baseline GDP. In ADAM, the medium-run effect is measured as the percentage change in the long-run equilibrium. The short run in ADAM is defined as the effect in year 3 (the year where the multiplier is at its highest). In principle, a more detailed input-output matrix could be used as an auxiliary model to calculate the impact on GDP of a pharmaceutical export shock in ADAM. However, this approach is not standard for ADAM and falls outside the scope of this memo.
Source: Own calculations based on the DEA model and ADAM.

In the DEA model in the short run, an increase in the demand for manufacturing exports creates a slightly larger increase in GDP compared to when the pharmaceutical industry exports increase. According to the DEA model, GDP increases by 1.69 percent following the export shock to the general manufacturing industry while GDP increases by 1.59 per cent following the export shock to the pharmaceutical industry; see chart 2. Taking into account the shock size of DKK 21 billion, the percentage increases in GDP illustrated in Chart 2 correspond to a GDP multiplier of 2.1 and 2.0 of each kroner increase in exports from the manufacturing and pharmaceutical industries, respectively.[13]

The varying impact on GDP depending on which industry experiences the shock is attributed to the triangular trade pattern observed in the DEA measurement framework. The data shows that consumers residing in rural areas, who are more likely to be employed in general manufacturing, have a smaller import share in their consumption than those in the pharmaceutical industry, who typically

[13] In ADAM the GDP multiplier of the impact on GDP is 1.68 in the short run and 0.25 in the long run. These multipliers are calculated using the percentage effects on GDP shown in chart 2 to calculate the change in GDP (in billion DKK) relative to 2023 GDP, scaled by the DKK 21 billion shock.

reside in urban areas. Therefore, a smaller portion of the income gains from a manufacturing demand shock is spent abroad, extending the length of the domestic spending chain. In isolation this will contribute to a larger impact from a general manufacturing export shock compared to a pharmaceutical export shock.[14]

Chart 2 shows that the short-run impact on GDP in the DEA model is larger compared to ADAM.[15] In isolation, the indirect effects through consumption included in the DEA model contribute to this larger GDP impact. However, other differences between the models also contribute to the differences in the impact of the export shock on aggregate GDP. For example, the DEA model is a static general equilibrium model, whereas ADAM is a dynamic SEM. The dynamic structure of ADAM means that factors like employment and consumption are in the process of adjusting to equilibrium, and this contributes to a smaller impact on GDP in ADAM compared to DEA. On the other hand, the lack of capital adjustment in the DEA model will in isolation contribute to a smaller impact on GDP, since increased capital increases the productivity of labour and thus output.[16]

[14] The differences may also stem from variations in the indirect effects related to trade in intermediates, for example if manufacturing in general requires more input from producers with larger labour inputs compared to pharmaceuticals. The DEA model also accounts for these differences since it considers variations in trade in intermediates based on both industry and geography.
[15] The short-run effect in ADAM is defined as the impact on GDP in year 3, when the impact of an export shock is at its highest. The effect is 0.94 per cent, 1.27 per cent, 1.36 per cent and 1.34 per cent in years 1, 2, 3 and 4 respectively.
[16] If we instead calculate the equilibrium effect on GDP in ADAM with sticky wages to make the models more comparable, the impact on GDP in ADAM is 1.9 per cent. See Statistics Denmark (2013) for further details on the impact of sticky wages in ADAM, especially how capital adjustments make the GDP impact higher than in the DEA model.

04

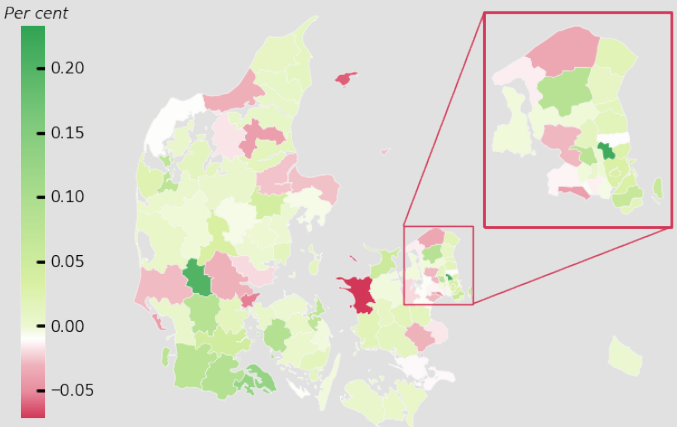
In the medium run, activity shifts between regions and industries

In this section we focus on the medium run distributional consequences of the two types of export demand shocks according to the DEA model. As mentioned, in the medium run in the DEA model, an export demand increase does not impact aggregate output but leads to a permanent increase in wages and prices.[17] However, results from the DEA model illustrate that, even though aggregate activity remains unchanged in the medium-run equilibrium, an export demand shock shifts real activity between production industries and geographical areas. This occurs because different export demand shocks impact wages in various geographical areas and industries differently.

CHART 3

An increase in general *manufacturing* exports shifts activity towards manufacturing municipalities

Medium-run: Percentage change in real GDP for each municipality following an increase in demand for manufacturing exports.

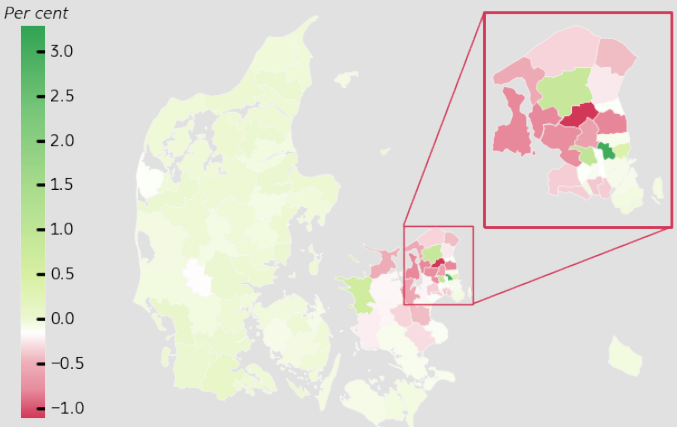


Note: The percentage change in real GDP is measured as the real GDP in equilibrium for each municipality in the version of the DEA model without nominal rigidities, relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

CHART 4

An increase in *pharmaceutical* exports mainly shifts activity between municipalities around Copenhagen area

Medium-run: Percentage change in real GDP for each municipality following an increase in demand for pharmaceutical exports.



Note: The percentage change in real GDP is measured as the real GDP in equilibrium for each municipality in the version of the DEA model without nominal rigidities, relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

The maps in chart 3 and chart 4 illustrate that in the medium term, when the export demand shock impacts the pharmaceutical industry, real activity increases by construction in the municipalities where the production is located on Zealand.

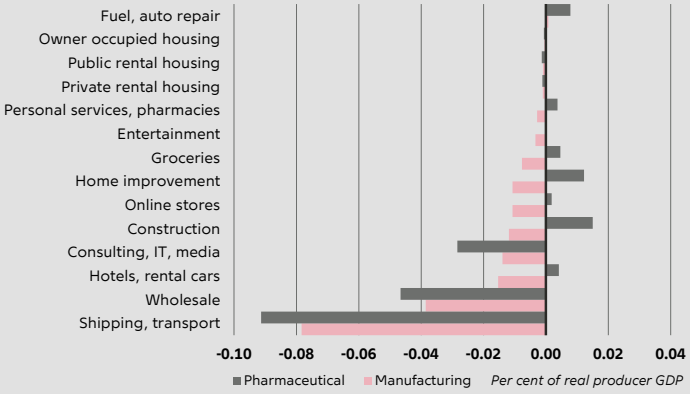
[17] Note that the Danish currency peg is included in the DEA model (as in ADAM), which means that monetary policy does not react to price increases.

It also increases real activity in some of the neighbouring municipalities in the Copenhagen area.[18] This could both be due to indirect demand effects stemming from consumption by consumers employed in the pharmaceutical industry or through demand for intermediates from the pharmaceutical producers. At the same time the export shock decreases real activity in areas like Allerød and Billund. [19] Real activity in these regions decreases because the export demand shock increases wages. This makes it harder for the companies in other municipalities to export their products. The labour force in these municipalities will therefore shift towards employment in less productive industries.[20]

CHART 5

An increase in pharmaceutical exports increases real production of industries supplying inputs…

Medium-run: Change in real producer GDP as a per cent of baseline real producer GDP.

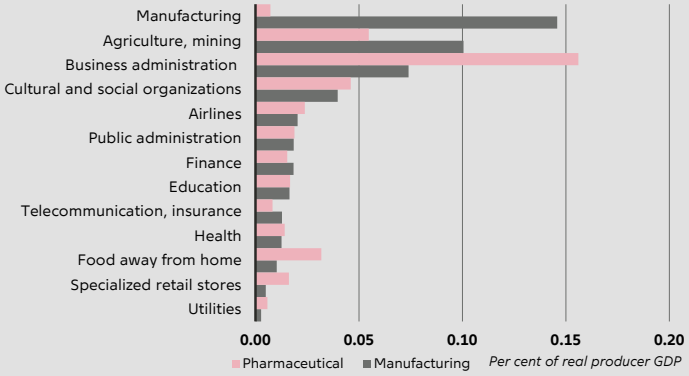


Note: The percentage change in real producer GDP is measured as the real producer GDP in equilibrium for each industry using the version of the DEA model without nominal rigidities, relative to the aggregate shock.
Source: Own calculations based on the DEA model.

CHART 6

…but decreases real production of other manufacturing producers

Medium-run: Change in real producer GDP as a per cent of baseline real producer GDP.



Note: The percentage change in real producer GDP is measured as the real producer GDP in equilibrium for each industry using the version of the DEA model without nominal rigidities, relative to the aggregate shock. The business administration industry includes janitorial services.
Source: Own calculations based on the DEA model.

In contrast to this, an increase in the export demand for general manufacturing increases real production in regions where manufacturing exports are important for overall production. This means that real output gains and losses are both distributed broadly across Denmark. For example, real output increases in both Billund and Sønderborg in Jutland but also in Gladsaxe and Hillerød. However, the increases are correspondingly much smaller compared to when the demand for pharmaceutical export increases since the same total increase in exports by construction are spread across more cells following an increase in the demand for manufacturing exports.

[18] Higher demand could lead to additional production facilities in other areas of Denmark, which would alter the regional effects of the shock. In this analysis, it is assumed that the pharmaceutical industry will use its current production facilities.
[19] The lower real activity in e.g. Allerød following the pharmaceutical export demand shock only indicates a reduction in the real GDP of Allerød. This implies that the value of goods produced in Allerød decreases. However, it does not necessarily mean that the workers producing these goods reside in Allerød. goods produced in Allerød decreases, which is not necessarily produced by workers living in Allerød.
[20] While real economic activity may shift between regions in the medium run due to these shocks, consumers do not relocate to different municipalities or change their main industry of employment (which together define their cell in the DEA model). However, following the shock, they can shift their labour supply to other regions – i.e. work in the same industry but in another municipality. Also, if they have secondary employment in another industry, they may switch that industry as a response to the shock.

The DEA model can also be used to examine how other industries are affected by the two different types of export demand shocks, as shown in chart 5 and 6. The chart illustrates important differences between the two types of shocks. When the demand for general manufacturing exports increases, the real production in manufacturing increases the most, followed by production in the agriculture and mining industries, which supply inputs to manufacturing.

When the increase in demand instead is isolated to an increase in demand for the pharmaceutical industry's production, the largest real increase is in the industries providing service input to the pharmaceutical industry: business administration and janitorial services. Real production in manufacturing decreases because pharmaceutical exports crowd out other manufacturing exports as wages increase. Since demand for other industries through the indirect effects of the export shock increases too, wage increases are not isolated to the manufacturing industry. The shift in production between industries has corresponding implications for employment.[21]

Even though aggregate output does not increase in the medium run following an export demand shock, aggregate consumption does increase; see chart 15 in the appendix. The rise in wages following an export demand shock increases the purchasing power of domestic consumers in terms of foreign goods and services, leading to improved terms of trade for Danish consumers. However, this does not necessarily mean that consumption gains are widespread across Denmark. As highlighted in charts 3 and 4, output gains and losses are differently distributed depending on the type of export shock.

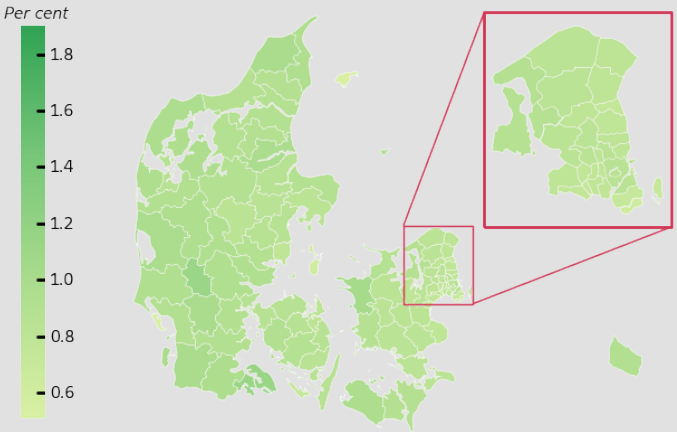
Chart 7 and chart 8 illustrate how consumption increases are distributed across geographical areas in response to the two different shocks. The two charts show that, following an increase in demand for manufacturing exports, consumption gains are spread across many municipalities, especially in Jutland. In contrast, a similar increase in demand for pharmaceutical exports results in consumption gains that are more concentrated in Zealand.

[21] See appendix chart 16 and 17. The chart shows that increases in labour supply in manufacturing following both types of export shocks mainly crowd out labour supply in the wholesale, consulting and IT, and home improvements industries.

CHART 7

Consumption increases are widespread across the country following a general increase in *manufacturing* exports

Medium-run: Percentage change in consumption for each municipality following an increase in demand for manufacturing exports.

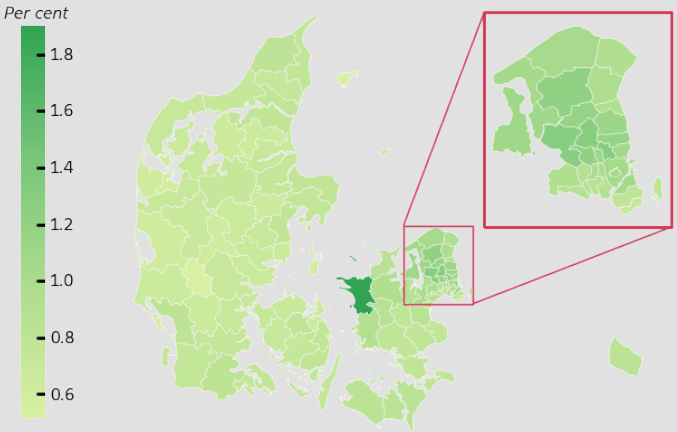


Note: The percentage change in real consumption is measured as the real consumption in equilibrium for each municipality in the version of the DEA model without nominal rigidities, relative to the baseline real consumption in each municipality.
Source: Own calculations based on the DEA model.

CHART 8

Consumption increases are more concentrated in Zealand following an increase in *pharmaceutical* exports

Medium-run: Percentage change in consumption for each municipality following an increase in demand for pharmaceutical exports.



Note: The percentage change in real consumption is measured as the real consumption in equilibrium for each municipality in the version of the DEA model without nominal rigidities, relative to the baseline real consumption in each municipality.
Source: Own calculations based on the DEA model.

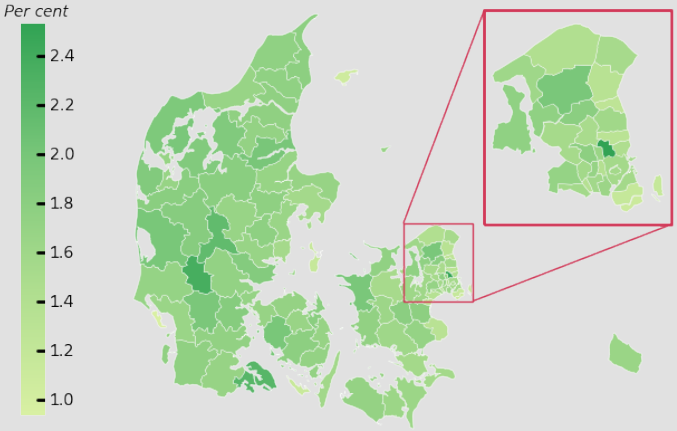
05
Short-run consequences

In the short run, an increase in aggregate demand within the DEA model can temporarily boost output and labour demand. Therefore, increased activity in one region does not necessarily lead to reduced activity in other regions. Charts 9 and 10 show that while the total output gain is larger when the demand increases for manufacturing exports compared to pharmaceutical exports (as illustrated in chart 2), the output gains are also more evenly distributed across Denmark. In contrast, the output gains in municipalities that experience an increase in demand for pharmaceutical exports are larger, and the aggregate output gain and higher demand for labour is concentrated among fewer municipalities. This is consistent with the latest developments in the Danish labour market; see for example the Ministry of Employment (2024).[22] [23]

CHART 9

An increase *manufacturing* exports increases activity in both Jutland and in Zealand

Short-run: Percentage change in real GDP for each municipality following an increase in demand for manufacturing exports.

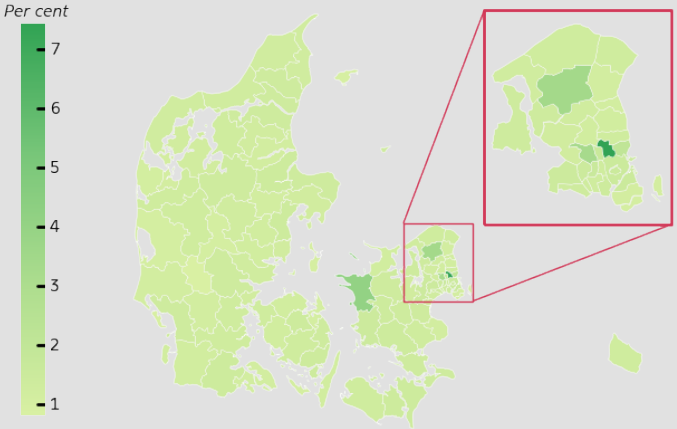


Note: The percentage change in real GDP is measured as the real GDP in equilibrium for each municipality in the version of the DEA model with sticky wages, relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

CHART 10

An increase *pharmaceutical* exports increases activity most significantly in a few municipalities in Zealand

Short-run: Percentage change in real GDP for each municipality following an increase in demand for manufacturing exports.



Note: The percentage change in real GDP is measured as the real GDP in equilibrium for each municipality in the version of the DEA model with sticky wages, relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

The more evenly distributed output gains result from both the construction of the two types of export shocks and the indirect effects captured by the DEA model. First, as previously discussed, when the demand for general manufacturing exports increases, more municipalities experience an increase in demand for goods produced within the municipality. In addition, when the demand for general manufacturing exports increases, the indirect demand

[22] In Danish only.
[23] See appendix chart 18 and 19 for the geographical distribution of employment changes.

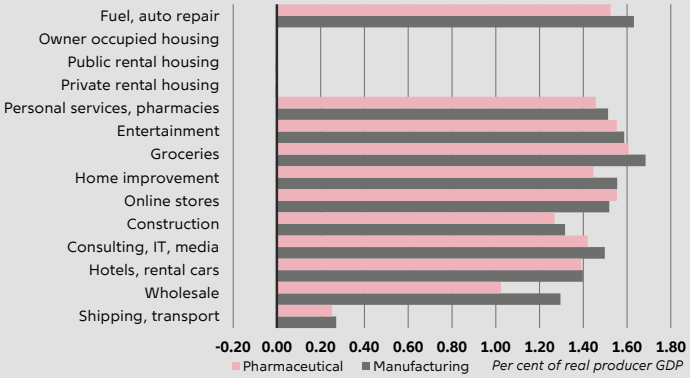
effects are more widespread. Since consumers employed in the manufacturing industry on average live in more rural areas, their consumption will be more widespread across all of Denmark compared to consumers employed in the pharmaceutical industry. Thus, the triangular trade pattern contributes to spreading the indirect gains of the manufacturing export shock across municipalities throughout Denmark.

The absence of cross-cell crowding out is also evident when looking at the change in real GDP producer gains across different industries. Charts 11 and 12 illustrate that following both demand shocks the manufacturing industry experiences the largest increase in producer real GDP. In contrast, in the medium run, increased activity in the pharmaceutical industry leads to only modest gains in the overall real GDP of the manufacturing sector due to crowding out.

CHART 11

Manufacturing producers experience the largest increase in real GDP...

Short-run: Change in producer real GDP gain as a per cent of baseline real producer GDP.

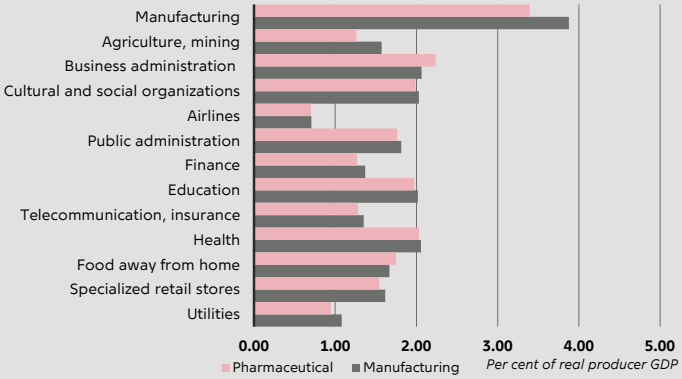


Note: The percentage change in real producer GDP is measured as the real producer GDP in equilibrium for each industry using the version of the DEA model with sticky wages, relative to the aggregate shock.
Source: Own calculations based on the DEA model.

CHART 12

...following an increase in both general manufacturing and pharmaceutical exports

Short-run: Change in producer real GDP gain as a per cent of baseline real producer GDP.



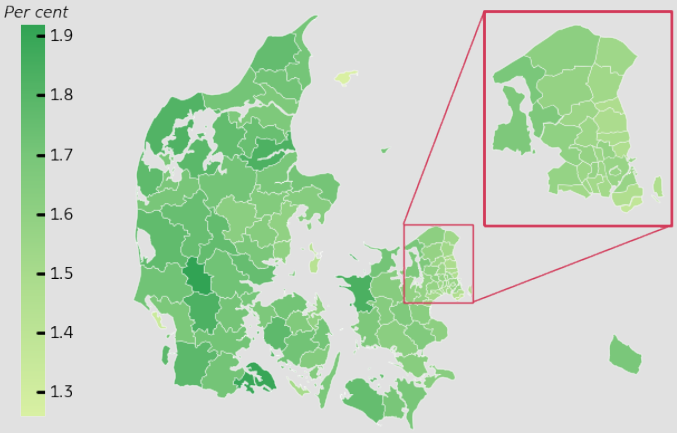
Note: The percentage change in real producer GDP is measured as the real producer GDP in equilibrium for each industry using the version of the DEA model with sticky wages, relative to the aggregate shock. The business administration industry includes janitorial services.
Source: Own calculations based on the DEA model.

Turning to the implications for consumption, the DEA model reveals that in the short run the aggregate impact on consumption is larger when the demand for manufacturing exports increases compared to pharmaceutical exports. This is mainly a result of larger aggregate impact on output, which in turns leads to larger effects on consumption due to the triangular trade pattern. The distribution of consumption gains across Danish municipalities following both types of export demand shocks are illustrated in charts 13 and 14. As for real GDP gains, real consumption gains following the increase in export demand for manufacturing goods are more evenly distributed across Denmark. In contrast, consumption gains are more concentrated among fewer municipalities following an increase in demand for pharmaceutical exports.

CHART 13

Consumption gains are widespread across municipalities in Denmark following an increase in *manufacturing* exports

Short-run: Change in consumption relative to baseline consumption.

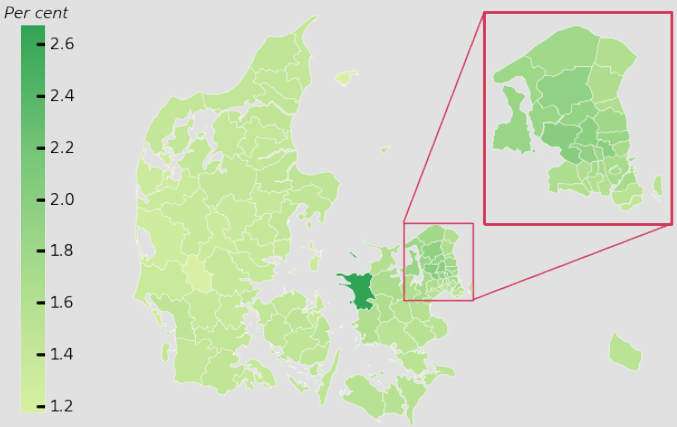


Note: The percentage change in real consumption is measured as the real consumption in equilibrium for each municipality in the version of the DEA model with sticky wages, relative to the baseline real consumption in each municipality.
Source: Own calculations based on the DEA model.

CHART 14

The largest consumption gains are concentrated in Kalundborg and Northern Zealand following an increase in *pharmaceutical* exports

Short-run: Change in consumption relative to baseline consumption.



Note: The percentage change in real consumption is measured as the real consumption in equilibrium for each municipality in the version of the DEA model with sticky wages, relative to the baseline real consumption in each municipality.
Source: Own calculations based on the DEA model.

06
Concluding remarks

This memo uses a new model of the Danish economy – the DEA model developed by Andersen et al. (2023) – to study the implications of the recent growth in Danish pharmaceutical exports. Specifically, the memo compares the economic consequences of an increase in the demand for pharmaceutical exports to a similar increase in the demand for manufacturing exports. With its high degree of heterogeneity, the DEA model provides new analytical opportunities compared to existing models of the Danish economy.

This heterogeneity contributes to a better understanding of the GDP multiplier size for shocks that affect different consumers differently. Importantly, Andersen et al. (2023) show that the import shares vary across geographical areas. This is relevant for the shocks studied in this memo, as manufacturing exports are generally produced in rural areas, where consumers tend to spend less abroad, while pharmaceutical exports are produced in urban areas with a higher import share in consumption. Consequently, the short-run GDP multiplier in DEA is slightly larger following a shock to manufacturing exports, since a larger share of the income gains are spent domestically. However, the aggregate impact on GDP from the two types of export shocks are quite similar. We also show that the aggregate effects are comparable to those predicted by the ADAM model.

The DEA model offers new insights into the distributional consequences of economic shocks in both the short and medium run. We show that, in the DEA model, short-run GDP and consumption gains from an export shock are more evenly distributed geographically when manufacturing exports increase compared to pharmaceutical exports. In the medium run, the DEA model predicts that while aggregate output remains unchanged, output increases in some municipalities and decreases in others, indicating that different geographical areas are affected differently by the export shock. The aggregate impact of zero therefore masks the fact that geographical areas are impacted differently by the export shock. Following an increase in demand for pharmaceutical exports, both gains and losses are concentrated around the Copenhagen area, whereas gains and losses from an increase in manufacturing exports are widespread across Denmark.

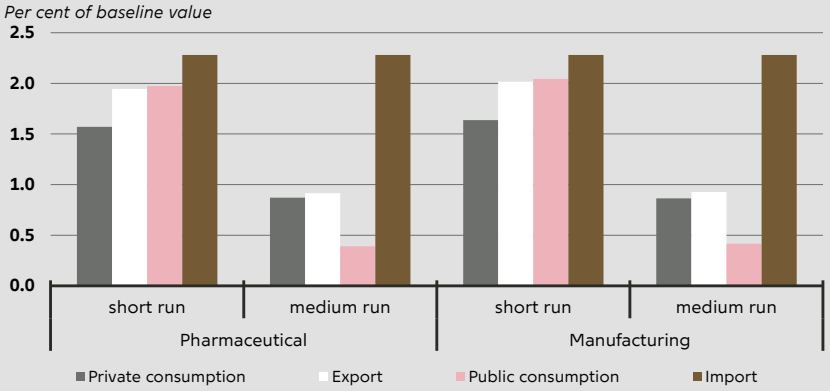
This memo highlights some of the new analytical opportunities that the DEA model provides, which Danmarks Nationalbank will continue to exploit whenever relevant questions arise. In ongoing work, Danmarks Nationalbank contributes to developing the model further by disaggregating the Danish financial accounts using the DEA measurement framework to include capital adjustments in the model.

07
Appendix

CHART 15

Impact on components of GDP of different export shocks in the short and medium run

The figure illustrates the impact of different export shocks on GDP components relative to baseline scenarios

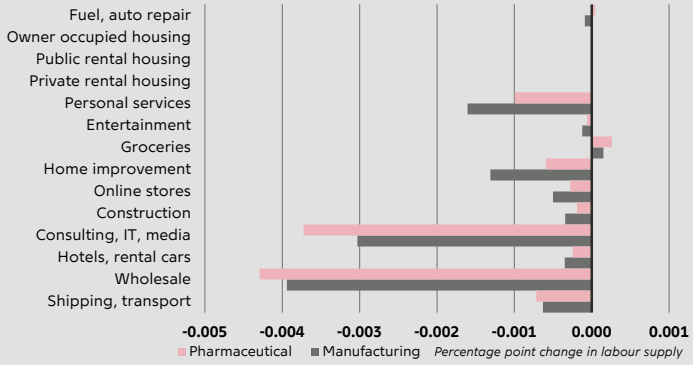


Note: The baseline value of the components corresponds to each components value in the DEA measurement framework in 2018. Investments are not included, since the DEA model does not include capital accumulation.
Source: Own calculations based on the DEA model.

CHART 16

The indirect effects of an increase in pharmaceutical exports increase the labour supply...

Medium-run: Percentage point change in labour supply for each industry as a share of total labour supply for non-manufacturers with more than one industry of employment

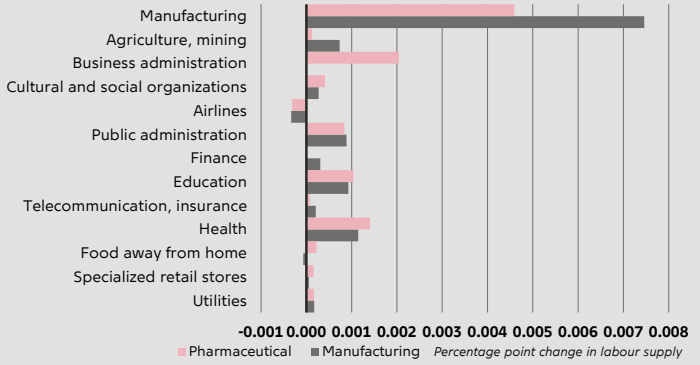


Note: The change in employment is measured by change in total labour supply (measured in hours) for a given industry, relative to the total labour supply of the non-manufacturers with more than one employment industries (a primary and a secondary employment). The calculations are based on the version of the DEA model without nominal rigidities.
Source: Own calculations based on the DEA model.

CHART 17

...in business administration services among individuals with secondary employments

Medium-run: Percentage point change in labour supply for each industry as a share of total labour supply for non-manufacturers with more than one industry of employment

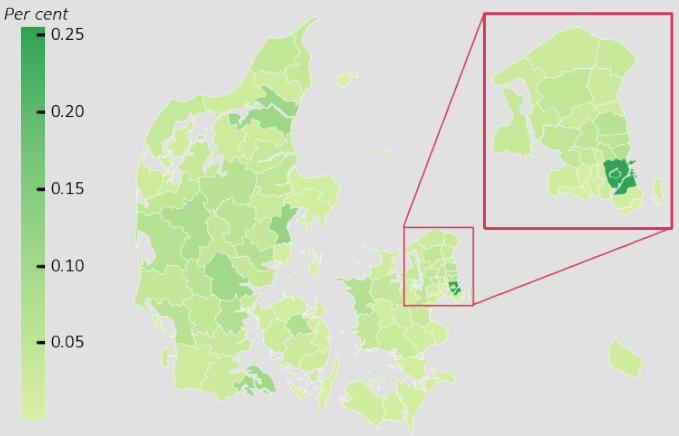


Note: The change in employment is measured by change in total labour supply (measured in hours) for a given industry, relative to the total labour supply of the non-manufacturers with more than one employment industries (a primary and a secondary employment). The calculations are based on the version of the DEA model without nominal rigidities.
Source: Own calculations based on the DEA model.

CHART 18

An increase in *manufacturing* exports increases employment in all of Denmark

Short-run: Change in real labour income in percentage points compared to baseline value

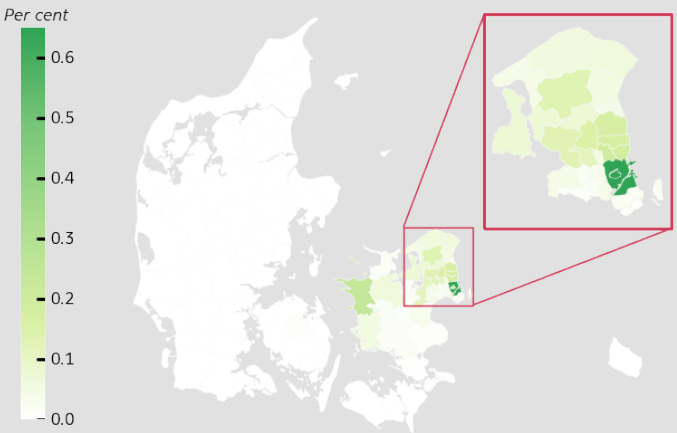


Note: The percentage change in employment is measured as the change in real labour income for each municipality in the version of the DEA model with sticky wages relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

CHART 19

An increase in *pharmaceutical* exports increases employment the most in Zealand

Short-run: Change in real labour income in percentage points compared to baseline value



Note: The percentage change in employment is measured as the change in real labour income for each municipality in the version of the DEA model with sticky wages relative to the baseline real GDP in each municipality.
Source: Own calculations based on the DEA model.

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