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Asger L. Andersen
Kilian Huber
Niels Johannesen
Ludwig Straub
Emil Toft Vestergaard

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ABSTRACT

We develop and analyze a new system of disaggregated economic accounts. The system breaks down national accounting positions into bilateral flows between consistently defined groups of consumers ("consumer cells"), groups of producers ("producer cells"), the government, and the rest of the world. We disaggregate the full circular flow of money, including consumer spending, labor compensation, firm surplus, foreign trade, taxes, and trade in intermediates. The measurement is comprehensive, so that the disaggregated flows add up to national aggregates and fulfill all national accounting identities. We implement the disaggregated system for small region-by-industry cells in Denmark. We present new facts on a "triangular trade" pattern across regions: spending by rural consumers disproportionately flows into urban regions, urban consumers spend more abroad, and export revenue mostly flows into rural regions. Building on a general equilibrium model with many consumer and producer cells, we illustrate that the structure of disaggregated economic accounts shapes the propagation of shocks: fiscal policy is more effective when targeted at rural consumers, and urban consumers gain the most from foreign trade.

Asger L. Andersen
University of Copenhagen
Department of Economics and
CEBI
Denmark
asger.lau.andersen@econ.ku.dk

Kilian Huber
Booth School of Business
University of Chicago
5807 S. Woodlawn Avenue
Chicago, IL 60637
and NBER
kilianhuber@uchicago.edu

Niels Johannesen
University of Copenhagen
Department of Economics
and CEBI
Denmark
niels.johannesen@econ.ku.dk

Ludwig Straub
Department of Economics
Harvard University
Littauer Center
Cambridge, MA 02138
and NBER
ludwigstraub@g.harvard.edu

Emil Toft Vestergaard
Danmarks Nationalbank
emilth@gmail.com

I Introduction

National accounts, pioneered by Simon Kuznets and Richard Stone in the 1930s and 1940s, measure aggregate flows—most notably national consumption, income, and output—as well as input-output trade among producer industries. However, modern national accounts contain little data on flows connecting smaller groups in the economy, for example, which consumers purchase goods from which producers, which producers pay income to which consumers, and which consumers and producers transact with the government and the rest of the world. The absence of comprehensively disaggregated economic accounts limits our understanding of how shocks propagate across the economy and how heterogeneity in the direct incidence of shocks affects aggregate and distributional outcomes.

In this paper, we take a step toward developing a full system of disaggregated economic accounts. Our system breaks down all national accounting positions into bilateral flows among consistently defined groups of consumers ("consumer cells"), groups of producers ("producer cells"), the government, and the rest of the world. The system reveals the sources of all inflows into each cell (e.g., which producer cells pay labor and profit income to each consumer cell) and the destinations of all outflows leaving a cell (e.g., which producer cells receive spending from each consumer cell). The disaggregated system is comprehensive, in the sense that individual flows add up to a corresponding national aggregate and that all accounting identities are satisfied (e.g., each cell's inflows equal its outflows).

Until now, there existed no methodology and few data sources that allow implementing a system of disaggregated economic accounts. We overcome these challenges in Denmark, where we combine a wide range of administrative data to measure disaggregated economic accounts at the level of small region-by-industry consumer and producer cells.[1] The data allow us to present new facts on the disaggregated circular flow of money across cells. For instance, we highlight a "triangular trade" pattern: rural spending disproportionately flows into urban regions; urban regions disproportionately spend abroad; and, in turn, money from abroad mostly flows into rural regions because they export more.

We complement the measured system with a disaggregated neoclassical macroeconomic model, calibrated to match the new data. The model reveals that the structure of disaggregated economic accounts shapes the distributional and aggregate consequences of economic shocks. First, we find that the effects of fiscal policy on aggregate welfare are very heterogeneous depending on which cells are targeted. The cell-specific aggregate multiplier is greater for consumer cells whose spending remains in the country for longer, which concretely means cells in rural regions, as shown in the triangular trade pattern. Second, we find that a uniform reduction in export

[1] Disaggregated data are available under disaggregatedaccounts.com.

tariffs has stronger direct incidence on rural consumers, but nonetheless improves the welfare of urban consumers by more once indirect spillovers are included. Both of these findings depend crucially on the structure of disaggregated economic accounts. We cannot replicate them with less comprehensive or coarser national accounting systems.

Methodology. Our methodology involves three steps: defining the level of disaggregation, assembling an aggregate circular flow of money, and disaggregating all individual flows. We define the level of disaggregation by grouping all parts of the economy, including persons, firm establishments, and government divisions, into cells. In principle, any cell grouping is possible, down to the level of individual persons and establishments at the most extreme end. For our implementation in Denmark, we assign every Danish adult to one of 2,700 consumer cells based on their industry of main employment and region of residence. We also assign every Danish establishment to one of 2,700 producer cells based on their industry and location. These cells are small, with the median consumer cell containing 658 adults and the median producer cell containing 47 establishments. We also include one cell each for the Danish government, the rest of the world, and capital accumulation. The region-by-industry grouping is useful because, as we illustrate below, many flows vary strongly with geography and industry and because many shocks, such as trade or targeted fiscal policy, affect regions and industries heterogeneously. We discuss in detail the advantages of other potential cell definitions and the roles played by different cell types in the system of disaggregated economic accounts.

To assemble an aggregate circular flow of money, we identify 36 national accounts positions that we want to disaggregate. We incorporate all positions from the production, income distribution, and use of income accounts of the standardized UN System of National Accounts. These positions include flows from consumers to producers (e.g., consumer spending), producers to consumers (e.g., labor and mixed income), between producers (e.g., intermediates trade), to and from the government (e.g., taxes and transfers), as well as all foreign exports and imports. We construct an aggregate circular flow by identifying which cell types are associated with each flow and defining accounting identities that hold at the aggregate level and at the level of individual cells (e.g., all consumer income equals all expenditures plus saving).

We then lay out two general approaches to disaggregating a national accounting position. A "bottom-up" approach uses microdata on individual flows (e.g., consumer payment transactions to retail establishments) to calculate cell-to-cell flows. Alternatively, a "top-down" approach distributes an aggregate flow across cells using an assignment algorithm informed by microdata. We use "bottom-up" approaches to disaggregate most positions, including consumer spending, labor compensation, mixed income, government transfers, and taxes, among others. For instance, to disaggregate consumer spending, we rely on transaction-level information on both consumers and retail establishments, provided by the largest Danish retail bank. Thanks to the representative microdata, the distribution of spending across broad consumer regions and receiving industries in the disaggregated spending flows is similar to data based on the national accounts and household surveys. To disaggregate a few flows not covered by nationally representative microdata, we rely on "top-down" algorithms. For instance, we disaggregate trade in intermediates using a gravity-based algorithm based on Leontief and Strout (1963) and informed by producer-to-producer trade microdata.

Facts. We analyze the disaggregated economic accounts to present facts on the circular flow of spending across region-by-industry cells. First, distance has a strong effect on consumer spending, labor compensation, and intermediate goods trade. Distance matters most for regular, in-person consumer spending (e.g., fuel, groceries) and less for spending on travel (e.g., hotels) and remote services (e.g., insurance and telecommunication). Second, consumer spending flows toward urban regions: the population size of a consumer cell's home region is almost always lower than the average size of regions receiving its spending (Glaeser et al. 2001; Handbury and Weinstein 2015). Similarly, net spending on intermediate goods by producers flows toward urban regions, which is mostly driven by the prevalence of service producers in cities (see Glaeser and Kohlhase 2004 and Rossi-Hansberg et al. 2023)

Third, we directly measure spending abroad and on foreign retailers in the Danske Bank data, complementing recent work on the consumption of imported goods (Borusyak and Jaravel 2021). We find that urban consumers allocate around 12 percent of their consumer spending abroad, while it is 8 percent for rural consumers. Fourth, exports are larger in rural regions, both relative to rural GDP as well as in absolute terms, mostly because exporting manufacturers are located in rural regions. Finally, net transfers by the government to consumers (transfers minus taxes) are larger in rural regions, but the government employs and purchases more in urban regions. On net, the government transfers money to urban regions.

Overall, the facts suggest that money flows across regions in a triangular pattern: from foreign countries into rural regions, then from rural into urban regions, and finally out of urban regions back to foreign countries. The government contributes to the urban bias of domestic flows through its stronger spending in urban regions.

Model. To understand how the structure of disaggregated economic accounts can matter for policymakers and researchers, we develop a static neoclassical model of an open macroeconomy, inspired by Acemoglu et al. (2012), Caliendo and Parro (2015), Caliendo et al. (2018), and Baqaee and Farhi (2019b, 2022a).[2] The model contains many domestic region-by-industry consumer and producer cells, foreign consumers and producers, as well as a government. This setup allows us to calibrate the model directly using the measured disaggregated economic accounts.

We view the calibrated model as a general tool that allows us to study the aggregate and distributional effects of shocks hitting some or all region-by-industry cells. This approach builds on a large literature that has used general equilibrium models to quantify shock propagation across regions and industries (e.g., Nakamura and Steinsson 2014; Farhi and Werning 2016; Chodorow-Reich 2019; Beraja et al. 2019; Faber and Gaubert 2019; Adão et al. 2020; Galle et al. 2023). In contrast to this existing work, our model allows shocks to propagate through a wide range of linkages between cells and uses the disaggregated economic accounts to calibrate the heterogeneous nature of these linkages. Our work also relates to an empirical literature using quasi-experimental techniques to estimate spillover effects across or within regions, but this work typically cannot identify all general equilibrium mechanisms that connect different cells (e.g., Greenstone et al. 2010; Huber 2018, 2023; Giroud and Mueller 2019; Aghion et al. 2020; Carvalho et al. 2021; Gabaix and Koijen 2022).

Applications. In a first set of applications, we study the effects of targeted fiscal policy on aggregate welfare. Specifically, for each consumer cell, we compute the welfare change experienced by the aggregate economy if that consumer cell receives a transfer from the government. We call this welfare change the "aggregate welfare multiplier" or "marginal value of public funds" (Hendren and Sprung-Keyser 2020) of a consumer cell.

We show theoretically and quantitatively that the aggregate welfare multiplier is very heterogeneous across consumer cells, varying with a cell's position in the disaggregated circular flow: the longer a transfer to a cell circulates in the domestic economy before leaving the country, the larger the cell's aggregate welfare multiplier. Intuitively, a transfer that circulates longer domestically generates more income for Danish consumers, raising Danish welfare along the way. In line with our triangular trade pattern, rural regions are associated with longer domestic circulation and therefore greater welfare multipliers.

We find these results in a frictionless, neoclassical model, despite Hulten's (1978) theorem. The reason is that there exist pecuniary externalities vis-a-vis the rest of the world that allow transfers to raise Danish welfare at the expense of welfare abroad. We confirm that similar results hold for output multipliers in a version of our model with nominal rigidities.

[2] Related literatures have investigated the macroeconomic effects of cross-industry and cross-regional trade among producers (Long Jr. and Plosser 1983; Horvath 2000; Jones 2011; Caliendo and Parro 2015; Baqaee and Farhi 2019a, 2020; Caliendo et al. 2019; Bigio and La'O 2020; Bachmann et al. 2022) as well as linkages in the presence of Keynesian frictions (Miyazawa 1976; Farhi and Werning 2014; Flynn, Patterson and Sturm 2021; Guerrieri, Lorenzoni, Straub and Werning 2021, 2022; Baqaee and Farhi 2022b; La'O and Tahbaz-Salehi 2022; Woodford 2022; Rubbo 2023a,b). See Baqaee and Rubbo (2023) for a review.

In a second set of applications, we revisit the gains from trade through the lens of our disaggregated economic accounts. Specifically, we study how a uniform reduction in export tariffs affects the distribution of welfare across consumer cells. Since rural producers export more, the direct incidence of tariff reductions falls mainly on rural producers and consumers. They benefit from higher export revenue and, as a result, higher incomes. However, the general equilibrium benefits accrue mostly to urban consumers, at odds with the direct incidence. The discrepancy between direct and general equilibrium incidence is driven by the structure of disaggregated economic accounts. The urban bias of consumer spending and domestic trade implies that urban consumers indirectly receive much of the additional export revenue. Moreover, the higher foreign spending of urban consumers implies that urban consumers are less affected by the rise in domestic prices due to the additional export revenue. Ultimately, it is the welfare of urban consumers that rises the most.

For both applications, we compare the results on fiscal policy and the gains from trade to results from models matching coarser systems of accounts. We find that the results crucially hinge on a fine level of disaggregation in the accounts, specifically on the inclusion of disaggregated consumer cells. Taken together, these findings suggest that disaggregated economic accounts can provide new insights into the propagation of shocks and policies and may thus aid in the design of new policy instruments.

II Disaggregated Economic Accounts in Relation to Existing Measurement

Richard Cantillon (1755) and François Quesnay (1758) first represented the national economy as a complex circular flow of money, with disaggregated consumer and producer groups (e.g., farmers, artisans, property owners) connected through bilateral consumption, income, and trade flows. This early work already envisioned that a system of national accounts should adhere to three ideas. First, it should record the heterogeneous bilateral flows connecting disaggregated consumer and producer groups, rather than just aggregate flows. Second, it should satisfy accounting identities linking consumption, income, and trade at the level of each disaggregated group as well as at the aggregate level. And third, it should capture transactions between disaggregated groups comprehensively, so that measured disaggregated flows add up to national aggregates.

Economists in the early 20$^{\text{th}}$ century brought these ideas closer to practice. Lahn (1903), Foster (1922), and Knight (1933) represented aggregate accounting identities in the circular flow of money. Kuznets et al. (1941) and Meade and Stone (1941) pioneered the measurement of the aggregate circular flow (i.e., aggregate consumption, income, and output). Leontief (1928; 1966) instead focused on disaggregation and measured bilateral trade between producer industries. The first United Nations (UN) Committee on National Income Statistics in 1947, chaired by Richard Stone, incorporated all this work into its recommended system of national accounts (Stone 1961). Modern accounts, standardized by the UN System of National Accounts, still follow this concept.[3]

Existing systems, however, have fallen short of the vision of Cantillon and Quesnay, namely they only disaggregate flows between producer groups. There is currently no system of accounts that comprehensively documents bilateral consumption and income flows between disaggregated consumer and producer groups within a country. The absence of bilateral consumption flows is particularly striking given that measuring consumption is a chief aim of national accounting (Barro 2021). The system of disaggregated economic accounts developed in this paper fills this gap.

Our work complements several recent measurement innovations. First, Chetty et al. (2023) develop high-frequency accounts for consumer and producer groups, which can support policy in real time. Second, distributional national accounts document income and wealth across consumer groups (Saez and Zucman 2016; Piketty et al. 2018; Blanchet et al. 2021). Recent work in this area focuses on top wealth shares (Saez and Zucman 2022; Smith et al. 2023) and saving rates of the rich (Mian et al. 2021). Third, transaction data can improve our understanding of national consumption dynamics (Aladangady et al. 2022; Ehrlich et al. 2022; Buda et al. 2022), heterogeneous consumption responses to shocks (e.g., Baker 2018; Vavra 2021; Cox et al. 2020; Baker and Kueng 2022; Andersen et al. 2023), business entry and exit (Glaeser et al. 2022), spending patterns across space (Davis et al. 2019; Agarwal et al. 2020; Dunn and Gholizadeh 2020; Allen et al. 2021; Miyauchi et al. 2022), and living standards across regions (Diamond and Moretti 2021).

Fourth, government registers document income flows between producers and consumers (e.g., Card et al. 2013; Adão et al. 2022) and trade between producers (e.g., Huneeus 2018; Dhyne et al. 2021; Bernard et al. 2022). Fifth, Paweenawat and Townsend (2021) describe how integrated financial accounts can improve analyses of inequality. Sixth, subnational social accounting matrices record cross-region trade among producers and can inform computational general equilibrium (CGE) models (Reinert and Roland-Holst 1997; Giesecke and Madden 2013), but do not measure disaggregated consumer flows across or within regions.[4] In that sense, disaggregated economic accounts could serve as a more refined input into CGE models. Seventh, Gabaix (2011) highlights that granular patterns shape macroeconomic outcomes. Eighth, the Social Connectedness Index (Bailey et al. 2018) and Social Capital Atlas (Chetty et al. 2022) measure friendships across regions and socioeconomic groups.

Disaggregated economic accounts are conceptually distinct from these existing approaches. First, we disaggregate the entire circular flow of money, rather than focusing on a subset of

[3]Some countries also provide regional statistics, as analyzed by Acemoglu and Dell (2010) and Gennaioli et al. (2013), but typically do not measure bilateral flows between regions comprehensively.

[4]CGE models usually assume that there is one representative consumer type in each region who consumes only locally. See also Costinot and Rodríguez-Clare (2014) who compare CGE models to quantitative trade models.

national accounting positions. Second, we focus on bilateral flows between producers, consumers, government, and the rest of the world, rather than just heterogeneity on the consumer or producer side. Third, disaggregated economic accounts are comprehensive, so that the sum of disaggregated flows equals national aggregates and satisfies national accounting identities within and across groups.

III The Methodology of Disaggregated Economic Accounts

In this section, we describe three steps toward measuring a system of disaggregated economic accounts: defining the level of disaggregation, assembling an aggregate circular flow, and applying either "top-down" or "bottom-up" disaggregation approaches.

III.A Defining the Level of Disaggregation

In the first step, we choose the level at which we will disaggregate the circular flow of economy. Concretely, this means that we group all parts of the economy—including individual persons, firm establishments, and government divisions—into cells. In principle, one can pick the level of cells flexibly. The most extreme choice would be to define cells at the level of individual persons and establishments, although data availability would make this approach difficult to implement.

In our measurement in Denmark, we define many cells for domestic producers and many for domestic consumers, but only one cell for the Danish government, one cell for all capital accumulation transactions, and one cell for the rest of the world.

For consumer cells, we assign all Danish adults to cells based on their region of residence and the industry paying the largest share of their income. There are 2,744 domestic consumer cells in total. The cells are formed from the interaction of 98 regions, one for each of the Danish municipalities, and 28 industries (listed in Table A.I). The industry classification includes industries selling directly to consumers and producers (e.g., food away from home, grocery stores, airlines), non-consumer-facing industries selling to producers (e.g., wholesale, manufacturing), and four industries for the non-working parts of the population (retired, students, unemployed, out of workforce).

For producer cells, we assign firm establishments to 2,646 cells, based on their region and production industry. There are 24 producer industries paying labor compensation to consumers ("work industries") as well as three producer industries providing housing services without any employees (private landlords, owner-occupied housing, government-owned housing). The individual producer and consumer cells are small, with 658 adults in the median consumer cell and 47 establishments in the median producer cell.

The region-by-industry breakdown is useful because, as we will illustrate below, many flows depend in important ways on geography (such as consumer spending) or industry (such as exports). Moreover, many shocks, such as trade shocks or targeted fiscal policy, affect regions and industries heterogeneously. There is also a practical side benefit to our cell definition, as we can observe region and industry across all underlying datasets. However, in general, it is not necessary to define the consumer and producer cells symmetrically. One could, for instance, choose a regional cut for consumers and an industry cut for producers. More generally, one could also define consumer cells by education, income, wealth, or other individual characteristics. Unlike region and industry, these other characteristics are either coarser (for education levels) or less stable (for income and wealth) than region and industry, although they may be useful for specific analyses.

We include one cell for the rest of the world, which represents all foreign consumers and producers, and one government cell, which represents the entire public sector and non-profit institutions serving households (NPISH). The main function of the government cell is to purchase output from domestic government-operated producers (so-called "domestic government spending" or "government consumption") and from abroad ("government imports") and to provide this output to consumers free of charge or at low nominal fees ("consumption of government output"). Government-operated producers are primarily in healthcare, public administration, education, and national defense (Figure A.V). We combine the government cell with NPISH, since both carry out similar activities and since the NPISH sector is very small. Finally, we include one capital accumulation cell, whose role we describe in Section III.B below.

Note that the disaggregated cell types differ from the UN System of National Accounts (SNA) classification, which contains five "institutional sectors:" non-financial corporations, financial corporations, government, NPISH, and households. The government, NPISH, and household sectors of the SNA are all simultaneously producers and consumers of output. In contrast, our disaggregated consumer cells do not produce output and our disaggregated producer cells include all establishments generating market and non-market output, including corporations, unincorporated businesses, government-owned firms (which sell output at market prices), and government-operated firms (which are run by government workers and provide mostly non-market output to consumers, e.g., public administration).

An important question when setting the level of disaggregation is whether consumer cells consist of individuals or households. It is difficult to draw the right boundaries of a household and to define consistent region and industry cells based on households, as household members may live in different regions (such as children supported by parents) and work in different main industries. By grouping individuals into cells, we circumvent these issues. One concern with an individual-level grouping is that there exist transfers between individuals (e.g., a parent supporting an adult child). Such transfers are recorded in the disaggregated economic accounts, however, because they appear as transfers between disaggregated consumer cells and the capital accumulation cell. In future work, one could directly measure disaggregated transfers between household members (or, more generally, between any two individuals) as a separate disaggregated flow (as in Andersen et al. 2020). In this paper, we carry out several robustness checks showing that none of the facts and application results hinge on the way we treat transfers.

A similar issue applies to producers, where one could use establishments or firms to define producer cells. The establishment-level grouping is natural for the analysis of region and industry cells, since establishments of one firm can belong to multiple regions and industries and since within-firm intermediates trade is already part of national input-output tables. In our system of disaggregated economic accounts, other types of within-firm transfers would appear as transfer flows between disaggregated producer cells and the capital accumulation cell, including transfers of internal capital (e.g., Matvos and Seru 2014; Biermann and Huber 2023), resources (e.g., Giroud and Mueller 2019), and technology (e.g., Giroud et al. 2023). In future work, one could measure such within-firm transfers in separate disaggregated datasets. Robustness checks below show that the facts and applications in this paper are not driven by the treatment of within-firm transfers.[5]

III.B Assembling an Aggregate Circular Flow

In the second step, we identify the national accounts positions that we want to disaggregate and assemble an aggregate circular flow of money for these positions. We build on the globally standardized definitions of positions from the SNA. We choose to disaggregate all positions found in the four opening accounts of the SNA: production, income distribution, income redistribution, and use of income. Overall, we disaggregate the 36 SNA positions listed in Table I. For each position, we identify which type of disaggregated cell originates the flow ("outflow from") and which receives the flow ("inflow to").

[5]Some flows are originally recorded at the firm level, for example, taxes and subsidies. In such cases, we use Danish institutional rules and proportionality assumptions to allocate the flows across establishments, as detailed in Section IV.C.

Table I: All flows in the Danish disaggregated economic accounts

	Disaggregated flow name	SNA code	Outflow from	Inflow to	Total value (bn DKK)
1	Domestic consumer spending	P.3[a]	Consumers	Producers	771.9
2	Foreign consumer spending	P.3[a,b]	Consumers	Rest of world	81.9
3	Consumer product taxes paid	D.21	Consumers	Government	173.2
4	Consumer non-product taxes paid	D.5	Consumers	Government	566.4
5	Consumer social contributions paid	D.61	Consumers	Government	181.1
6	Consumer interest paid	D.41	Consumers	Capital acc.	29.7
7	Consumer natural resource rents paid	D.45	Consumers	Capital acc.	3.4
8	Consumer other transfers paid	D.7	Consumers	Capital acc.	44.8
9	Consumer gross saving	B.8g	Consumers	Capital acc.	130.0
10	Labor compensation paid by domestic producers	D.1	Producers	Consumers	1,132.9
11	Mixed income from non-corporate producers	B.3g	Producers	Consumers	80.7
12	Surplus of corporate producers to consumers (dividends)	D.42	Producers	Consumers	38.4
13	Surplus of owner-occupied housing to consumers	B.2g	Producers	Consumers	83.3
14	Consumer social benefits received	D.62	Government	Consumers	422.2
15	Consumer adjustment for pension entitlements received	D.8	Government	Consumers	92.5
16	Consumer interest received	D.41	Capital acc.	Consumers	5.3
17	Consumer pension investment income	D.44	Capital acc.	Consumers	75.5
18	Consumer natural resource rents received	D.45	Capital acc.	Consumers	3.4
19	Consumer other transfers received	D.7	Capital acc.	Consumers	39.2
20	Labor compensation paid by foreign producers	D.1	Rest of world	Consumers	8.9
21	Domestic intermediates	P.2[c]	Producers	Producers	1,423.4
22	Dividends and surplus of government-owned/operated producers to government	D.42	Producers	Government	67.9
23	Producer product and import taxes paid	D.21	Producers	Government	71.9
24	Producer net production-related taxes	D.29 - D.39	Producers	Government	20.9
25	Producer taxes paid on income	D.5	Producers	Government	61.9
26	Producer net interest, transfers, and saving	(D.41 + D.43 + D.44+ D.7) [net outflow] + D.45 + B.8g - D.42 rec.+ D.42 to rest of world[b]	Producers	Capital acc.	409.9
27	Producer imports	P.7[c]	Producers	Rest of world	792.3
28	Labor compensation paid to foreign workers	D.1	Producers	Rest of world	21.4
29	Domestic government spending	P.3[c]	Government	Producers	572.3
30	Domestic capital accumulation spending	P.1[c]	Capital acc.	Producers	359.5
31	Producer exports	P.6[c]	Rest of world	Producers	1,077.9
32	Government imports	P.7[c]	Government	Rest of world	4.3
33	Government net interest, transfers, and saving	(D.41 + D.7) [net outflow] + B.8g - D.44 - D.45[d]	Government	Capital acc.	52.0
34	Capital accumulation cell imports	P.7[c]	Capital acc.	Rest of world	98.9
35	Aggregate trade balance	P.6 - P.7[b]	Rest of world	Capital acc.	88
36	Consumption of government output	P.3	Provided free of charge to consumers		578.6

Notes: The table lists all the individual flows that make up the measured disaggregated economic accounts in Denmark. "Related SNA code" indicates the closest analog to the disaggregated flow in the UN SNA. "Total value" is the total in the Danish disaggregated economic accounts for 2018. Outflows/inflows are defined in terms of financial flows, so goods flow in the opposite direction. a: disaggregated flow excludes product taxes, unlike SNA (Section IV.A). b: net-of-tax foreign consumer spending is greater in disaggregated flow than in SNA (Footnote 10 and Appendix P). c: disaggregated flow is constructed by measuring output of consumer-facing producers in terms of sales, whereas SNA measures output using trade margins (Section IV.C). d: disaggregated flow uses a different definition of government saving than SNA (Appendix P).

We do not disaggregate the remaining SNA positions, which are found in the capital accumulation and balance sheets accounts. Instead, we assign all transaction between our disaggregated cells and these SNA accounts to the capital accumulation cell. In that sense, the capital accumulation cell serves as the counter-party for all flows related to capital accumulation, including saving, financial transfers, and investment transactions.[6] An extended system could include multiple capital accumulation cells, one each for type of capital-accumulating institution (e.g., commercial versus investment banks) and for different producer cells trading investment goods with each other (vom Lehn and Winberry 2022). We leave such disaggregation to future work.

Constructing an aggregate circular flow requires manipulating some SNA positions. The SNA production account and the input-output tables generally report pre-tax values, for instance, for intermediates trade. In contrast, the use of income account reports tax-inclusive values, for instance, for consumer spending. We represent all flows in pre-tax values, which requires calculating total taxes paid by different cell types.

With the information of Table I in hand, we can now design so-called "T-tables" for every cell type. The tables show that the inflows and outflows for every cell type exactly balance. As a result, accounting identities hold both at the aggregate level and at the cell level. For instance, the accounting identity for consumer cell i says that

$$\begin{aligned}&\text{Domestic consumer spending}_i + \text{Foreign consumer spending}_i\\&+ \text{Consumer taxes}_i + \text{Interest, transfers, and saving paid}_i\\&= \text{Labor comp}_i + \text{Producer dividends, mixed inc, and surplus}_i\\&+ \text{Government benefits}_i + \text{Interest and transfers rec}_i,\end{aligned} \tag{1}$$

whereas the accounting identity for producer cell j says that

$$\begin{aligned}&\text{Domestic intermediate spending}_j + \text{Labor comp}_j\\&+ \text{Producer dividends, mixed inc, and surplus}_j\\&+ \text{Dividends and surplus of government producers}\\&+ \text{Producer net taxes} + \text{Producer net interest, transfers, and saving paid}_j + \text{Imports}_j\\&= \text{Domestic intermediate sales}_j + \text{Domestic consumer spending}_j\\&+ \text{Domestic government spending}_j + \text{Domestic capital acc. spending}_j + \text{Exports}_j.\end{aligned}$$

[6]Note that national accounts differentiate between the finance industry, which sells financial services, versus the capital accounts, which record saving, financial transfers, and investment transactions. Establishments in the finance industry belong to one of the many producer cells, since they generate output and sell to consumers. In contrast, all capital accumulation transactions for the entire economy are carried out by the one capital accumulation cell.

We present the T-tables and accounting identities for all cell types in Appendix B and use them to structure our measurement.

III.C "Bottom-Up" and "Top-Down" Disaggregation Approaches

The goal of the measurement is to disaggregate the 36 SNA positions of Table I. Typical national accounts based on the SNA contain about 10,000 entries. In contrast, disaggregated economic accounts in Denmark will include around 43 million entries.

We employ two approaches to disaggregating a national accounting flow: "bottom-up" and "top-down." The bottom-up approach uses detailed microdata on individual transactions between consumers and producers, such as individual spending transactions. Adding up all transactions between two cells and, if appropriate, weighting to match the underlying population produces a cell-to-cell bilateral flow. An advantage of the bottom-up approach is that the unweighted sum of the bilateral flows immediately reveals how comprehensively the microdata capture an aggregate flow.

The top-down approach decomposes an aggregate position into bilateral flows using an algorithm, which needs to be calibrated using economic parameters (e.g., the effect of distance on trade) and microdata on cell characteristics (e.g., total employment of cells). We discuss in the measurement section how researchers can estimate the necessary parameters and apply them in algorithms.

IV Measurement of Disaggregated Economic Accounts in Denmark

We implement a comprehensive measurement exercise for the Danish economy in 2018. We outline the main steps in this section and provide details as laid out in Appendix C. The disaggregated data are available under disaggregatedaccounts.com.

IV.A Disaggregated Consumer Spending

The disaggregated consumer spending flows are the most novel parts of our measurement, since nationally representative data linking consumers and producers are not commonly available. We measure how much each consumer cell spends on every domestic producer cell and the rest of the world. The closest corresponding position in the UN SNA is P.3, national final consumption expenditure. However, P.3 includes both spending flowing to producers and product taxes (e.g., value added taxes, import duties). In contrast, our spending flows only record spending flowing to producers, whereas taxes appear in separate disaggregated flows. We take four steps to disaggregate consumer spending, as detailed in Appendix E.

Step 1: Bank transactions. The first step uses administrative transaction-level data from Danske Bank. The sample consists of all adults who held their main bank account at Danske Bank and conducted at least one spending transaction per month in 2018 and 2019. The sample covers 20% of Danish consumers and is representative in terms of age, income, and asset holdings (Table A.II). We infer consumers' home region from their address and work industry from incoming salary payments. The detailed microdata necessary to construct the disaggregated spending flows are only available for the years 2018 and 2019. We include both years in the sample to maximize observations.

Crucially, the data allow us to identify the merchant establishments receiving payment for a wide range of transactions, including payments by credit and debit cards, direct debits, bank transfers to producers, and mobile applications. We observe transaction-level information on the merchant independent of whether the merchant is a Danske Bank customer or not. We extract the merchant's address and category code (MCC, indicating the type of merchant) from strings associated with transactions. We then develop a novel cross-walk between MCC and industry codes (ISIC/NACE), so that we can match the industry of the merchant to the industry codes used in the disaggregated income and trade flows. In a few cases, we do not observe merchants' region and/or industry, so we assign these transactions to merchants in proportion to the observed spending of the same consumer cell using the same means of payment.

We observe cash withdrawals but not the merchants receiving cash payments, so we assume that consumers spend cash withdrawals in proportion to in-person card payments (separately for withdrawals in Denmark and abroad). Cash withdrawals are only 7% of aggregate transaction value, so our disaggregated consumer spending flows are relatively insensitive to this assumption.

We mostly treat online spending the same way as in-person spending, so the region of online merchants refers to the distribution centers delivering the good. We make an exception to this general rule for online spending on a few subindustries where the delivery of goods or services is entirely in person (e.g., cinemas, hotels). For these industries, discussed in Appendix E.E, we assign online spending across regions using the regional distribution of in-person spending, which avoids errors due the location of remote payment terminals. For the largest online merchants in each industry, we check by hand that the merchant addresses are indeed locations of relevant distribution centers.

As an additional accuracy check, we verify that the within-industry distribution of spending received by different regions is close to the within-industry share of labor compensation paid (Figure A.III). This indicates that the disaggregated spending flows are assigned to regions where establishments actually produce goods and services. This finding is key because it implies that the disaggregated spending flows are consistent with other disaggregated flows, in particular labor compensation and intermediates trade. In that sense, we can trace the flow of money across producer establishments in a consistent way using the disaggregated economic accounts.

To complete the first step, we aggregate all spending transactions going from a consumer cell to a producer cell and then scale up by each cell's ratio of consumers in the Danske Bank sample to the population.

Step 2: Spending outside bank transactions. In the second step, we augment the measurement with government data on housing, financial services, vehicles, and water and waste services (see details in Appendix E.F). Spending on these four goods is often not cleanly observed in bank transactions. However, we can measure such spending by combining administrative government and bank data. Notably, the government income register directly records the rental value of owner-occupied housing, interest expenses, and vehicle registrations for every individual.[7]

We compare the disaggregated consumer spending flows produced after the second step with national accounts personal consumption data from 2018. Both include product taxes paid. Spending patterns by industry are very similar (Figure I). It is not clear to what extent remaining differences reflect errors in the disaggregated flows or the national accounts, since both contain some statistical error due to sampling and assumptions.[8] Spending shares by consumer region in the disaggregated flows and the Danish household budget survey are also similar (Figure A.I). We additionally have access to a longer time series of aggregate card spending in the Danske Bank data, which evolves similarly to card spending recorded by Statistics Denmark (Figure A.II).

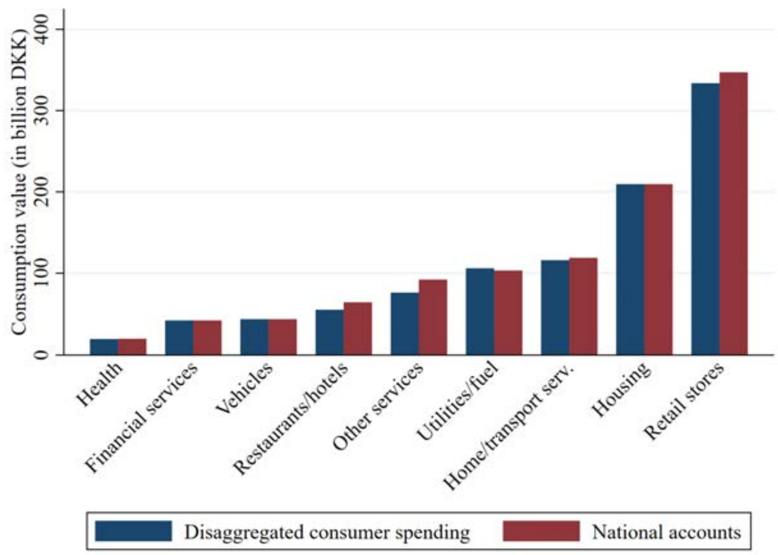
Step 3: Rescaling. In the third step, we scale every cell-to-cell spending observation by a common scaling factor, so that, in aggregate, our disaggregated consumer spending flows match national gross spending in 2018 (SNA P.3). Aggregate spending according to the unscaled disaggregated flows is 3% larger than the 2018 national accounts value, largely because we include both 2018 and 2019 in the bank data sample.

Step 4: Subtracting product taxes. In the fourth and final step, we measure product taxes paid by Danish consumers as part of their consumer spending (SNA D.21). National accounts data allow us to calculate the product tax rate paid on each industry's products as well as the import tax rate paid on products of foreign industries (details in Appendix F). We subtract product taxes

[7]According to national accounting conventions, homeowners living in their own property rent to themselves, so that owner-occupied rents are simultaneously counted as consumer spending and rental income. In the disaggregated economic accounts, consumer cells transact with the producer cell "owner-occupied housing" to pay rent and receive income for their owner-occupied housing (see Appendix E.F.1).

[8]For instance, national accounts in part rely on retail sales indices to measure consumer spending, which requires assumptions on spending by foreigners. In contrast, we directly observe spending by Danes and can exclude spending by foreigners.

Figure I: Consumer spending in the disaggregated accounts versus national accounts



Notes: The figure compares spending aggregated by receiving industry from the disaggregated spending flows with national accounts consumption data. Housing spending is constructed using a bottom-up approach for owner-occupied housing and a top-down approach for rented housing. Vehicles, financial services, and water and waste (part of utilities) are constructed using a top-down approach, so aggregates in the transaction data and national accounts match by construction. The remaining categories are constructed using a bottom-up approach, so there is no mechanical reason that these aggregates should match. For details, see Appendix E.

from each gross consumer spending flow to produce the final disaggregated consumer spending flows.

IV.B Disaggregated Consumer Outflows and Income

We detail the measurement of flows from consumers to the government in Appendix G and to the capital accumulation cell in Appendix H. To give an idea, we observe individual-level income taxes paid in the government registers and use a bottom-up summation to calculate total taxes paid per cell (SNA D.5). By far the largest position flowing from consumers to the capital accumulation cell is interest paid, which we measure using individual-level interest payments reported in the government tax register (SNA D.41). The aggregates of such bottom-up calculations are typically slightly lower than the national accounts aggregate, mostly because our sample contains only adults, so we ultimately scale each cell-level observation by a common scaling factor to match the national aggregate exactly.

We measure different types of income paid to each consumer cell by each producer cell in Denmark and by foreign producers (details in Appendix J and Appendix I). For instance, we measure disaggregated labor compensation flows bottom-up, drawing on the administrative tax and employment registers, which jointly reveal how much each producer establishment pays every individual in labor income and pension contributions (SNA D.1). Similarly, we record mixed income bottom-up to capture the income of owners of privately owned, non-corporate firms (SNA B.3G). We also directly observe individual-level operating surplus (SNA B.2G), which corresponds to the surplus of homeowners letting housing to themselves, in the government income register. To assign dividends of Danish corporations (SNA D.42), we rely on individual-level data on dividend income and assume that all cells hold a diversified portfolio of Danish corporations.

Consumers receive income from the government through various benefit programs, which we measure bottom-up using individual-level data from government registers (SNA D.62, see Appendix K). We disaggregate flows received from the capital accumulation cell, such as interest (SNA D.41), using procedures analogous to the ones for interest paid (see Appendix L).

IV.C Disaggregated Producer Flows

We measure trade in intermediate goods between each producer cell and every other domestic producer cell, net of product taxes (SNA P.2). Unlike for consumer spending, we do not have nationally representative microdata. Instead, we build on a top-down approach that was pioneered by Leontief and Strout (1963) and is frequently used in spatial economics today (e.g., Rodríguez-Clare et al. 2022). This approach employs a gravity model to convert the cross-industry table of intermediates trade, provided in the national accounts, to a region-by-industry matrix. All details are in Appendix M.

We estimate how trade varies with distance separately for every combination of supplier and user industries, using data on 5 million producer-to-producer transactions from the business service provider CrediWire (see Figure A.IV and Appendix M.B). We then apply an iterative algorithm that ensures the trade flows are consistent with the estimated distance elasticities and with the labor compensation shares of different regions within the same industry. We start the regional disaggregation procedure with 173 fine industries and then aggregate, so that the resulting trade flows contain substantial heterogeneity across cells.[9]

We directly observe exports (SNA P.6) and imports (SNA P.7) of each Danish manufacturing firm and assign these firm-level exports and imports to establishments using information on the labor compensation shares and occupations of workers (details in Appendix N). For instance, we assign the exports of manufacturing firms in proportion to the labor compensation paid to manufacturing workers at each establishment. We disaggregate exports and imports of non-

[9]We also face the challenge that national accounts do not report the sales value of goods sold by consumer-facing industries, but only "trade margins" (final value minus purchase value of goods). We convert the disaggregated intermediates trade flows so that they measure actual sales values for consumer-facing industries, thereby making it consistent with our consumer spending flows.

manufacturing firms using labor compensation shares of regions within the fine industries. We allocate spending by foreign consumers in Denmark, which includes tourist spending and counts as exports in the national accounts, using industry-level data on tourist purchases and regional data on hotel stays.

To disaggregate sales to the government ("domestic government spending," SNA P.3) and to the capital accumulation cell ("domestic capital accumulation spending," SNA P.1), we assume that a producer cell's share in the total sales of its industry to the government or capital accumulation equals its labor compensation share in the industry (at the level of 173 industries, details in Appendix M). We additionally measure labor compensation paid to foreigners using data on workers with a foreign address (details in Appendix I) and dividends paid to the government using hand-collected data on government-owned corporations (SNA D.42, details in Appendix O).

The rates at which producers pay taxes and receive subsidies differ strongly by industry. We measure the totals by industry separately for each type of taxes paid (e.g., on value added, income, payroll) and subsidies received (e.g., transfers to agriculture). We then allocate the industry total across producer cells using each cell's within-industry share in labor compensation paid (details in Appendix F). The only exception are income taxes, which we allocate in proportion to accounting profits (sales minus intermediates minus labor compensation). Finally, we calculate the net of interest, transfers, and saving of each producer cell as the difference between total inflows and outflows of each cell (see Appendix P).

IV.D Remaining Government, Rest of the World, and Capital Accumulation Flows

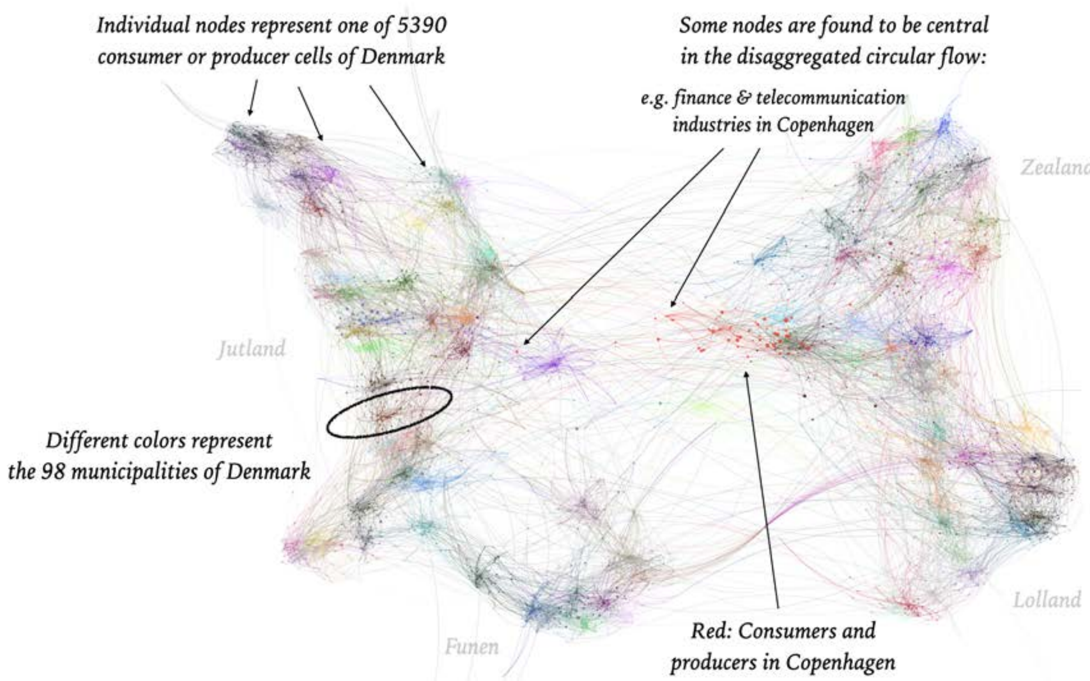
We finally measure all remaining flows for the government, rest of the world, and capital accumulation cells. This step ensures that all cells conform to accounting identities.

The remaining flows include imports of the government and capital accumulation cells, which are directly reported in the national accounts, the latter as imports of investment goods, valuables, and inventory. We measure government net interest, transfers, and saving as the difference between all other government outflows and inflows (see Appendix P). Finally, we define the trade balance as the money entering Denmark due to its net exports.[10]

We also measure each consumer cell's consumption of government output by combining individual-level government and Danske Bank data (details in Appendix Q). Since there are no financial flows associated with this consumption, it does not appear in the consumer account (equation 1).

[10] The Danish trade balance in our data is slightly below the national accounts trade balance (SNA P.6 - P.7) because the disaggregated spending flows contain a slightly higher value for foreign consumer spending (see Appendix P).

Figure II: The disaggregated circular flow of money



Notes: Nodes are all consumer and producer cells in Denmark. We draw a link between two cells if the cell-to-cell flow is among the top five outflows per cell or the top inflow per cell.

IV.E Visualizing the Disaggregated Circular Flow in Denmark

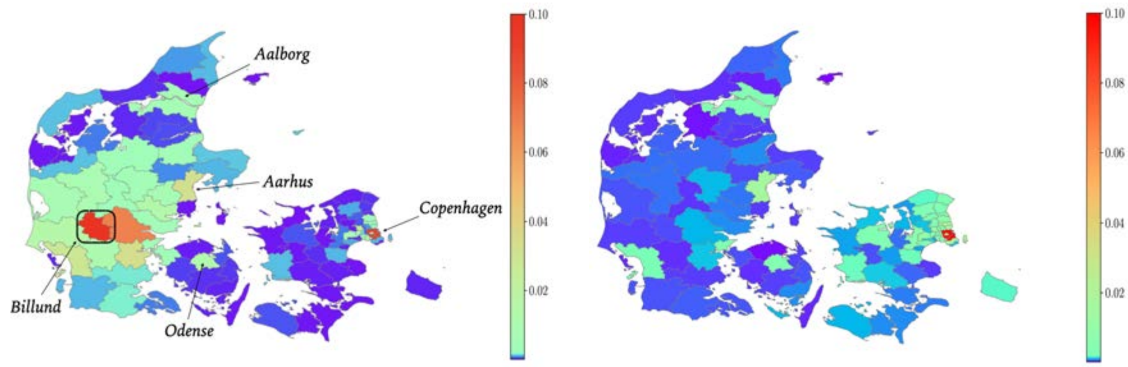
We conclude the measurement section by plotting the disaggregated circular flow of money in Figure II. Classical circular flows, inspired by Lahn (1903), Foster (1922), and Knight (1933), contain only a handful of nodes for consumer, producer, and government groups at the national level. In contrast, our disaggregated circular flow contains 5,390 nodes, one for each region-by-industry consumer and producer cell in Denmark. Nodes lying in the same region share the same color. Node size on the plot is proportional to a cell's economic size, measured as the square root of all inflows into the cell.

We visualize cell-to-cell flows by drawing a link from a source cell to a receiving cell if the sum of all flows between the two cells is among the five largest outflows for the source cell or the single largest inflow for the receiving cell. We let an algorithm ("ForceAtlas 2", Jacomy et al. 2014) arrange the nodes, so that cell pairs with larger pairwise flows are located next to each other.

A few patterns are noteworthy. First, nodes in the same region (and color) cluster together. The shape of the graph is strikingly similar to the geography of Denmark: the large cluster of nodes on the left is the continental western part of Denmark, the small cluster in the bottom is the central island Funen (with major city Odense), and the large eastern island Zealand with

Figure III: Examples of spending shares across regions

(a) Manufacturing workers in Billund (b) Restaurant workers in Copenhagen



Note: We plot the fraction of spending received by producers in each region, for spending by restaurant workers in Billund, which is the location of the Lego headquarter (Panel a), and Copenhagen (Panel b), which is the capital. The scale is truncated at 0.10. We include only spending to Danish producers in the calculations.

the capital Copenhagen (red) lies on the right. However, there are notable deviations from the geography of Denmark. For example, all Copenhagen cells, especially the Copenhagen airline, shipping, telecommunications, insurance, and finance industries (red central nodes), sit much more centrally in the plot than the eastern location of Copenhagen would suggest, mirroring their central position in the disaggregated circular flow.

V Facts Based on Disaggregated Economic Accounts in Denmark

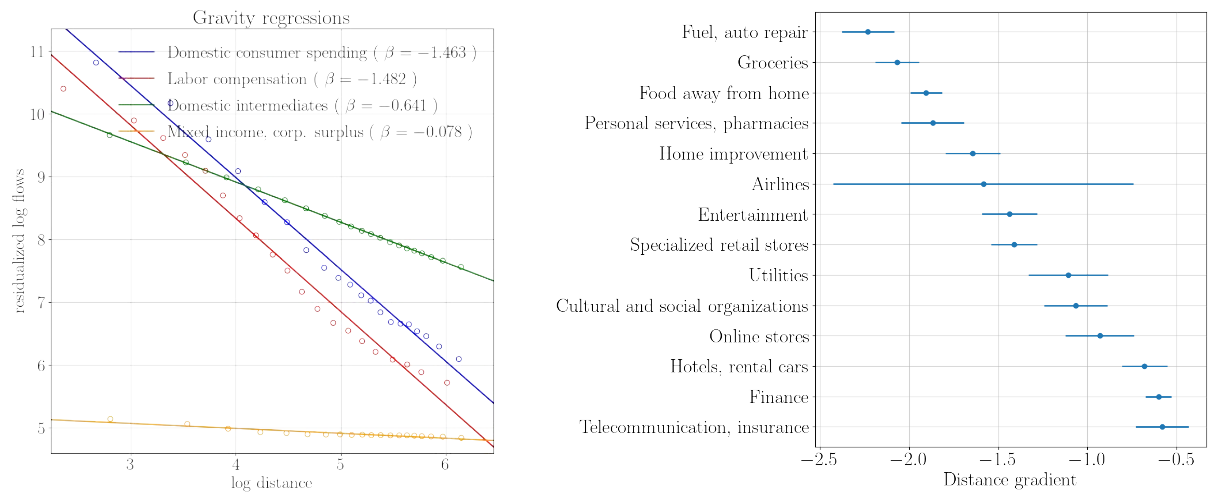
We analyze the disaggregated economic accounts to present facts about how different parts of the Danish economy are connected. Taken together, the facts will describe a "triangular trade" pattern across space: spending by rural consumers disproportionately flows into urban regions (Section V.B); urban consumers disproportionately spend their income abroad (Section V.C); and export revenue mostly flows from abroad into rural regions (Section V.D).

V.A Flows are Regionally Concentrated

We begin by exploring the role of geographic distance for domestic consumer spending. We plot the geographical distribution of domestic consumer spending for manufacturing workers living in rural Billund (Figure IIIa) and restaurant workers living in the capital Copenhagen (Figure IIIb). In both cases, spending is regionally concentrated and decreases with distance. However, deviating from the pattern of regional concentration, a large share of spending from rural Billund goes to the largest cities Aalborg, Aarhus, Odense, and Copenhagen. In contrast, little spending from Copenhagen flows to rural and far-away regions.

Figure IV: Gravity

(a) Across types of flows (b) Across receiving industries for consumer spending



Notes: Panel a shows binned scatter plots estimated separately for different flows using equation (2). We plot averages of $\overline{\alpha} + \overline{\delta} + \beta \times \log \text{ distance}_{ij} + \epsilon_{ij}$ for 20 evenly sized bins of distance. Flows are in log DKK and distance is in log driving km. Flows are residualized using fixed effects for source cells and receiving cells. We add the mean of log flows to the residualized variables. We exclude observations with zero distance or zero flow. The solid line is the line of best fit, estimated using the cell-level data. Panel b repeats the estimation for consumer spending by receiving industry. Figure A.VIII plots the analogue for labor compensation flows. The horizontal lines show 95% confidence intervals. Standard errors are two-way clustered by origin and destination cell.

We formally study the role of distance by estimating gravity specifications. We analyze the relation between driving distance (measured using Google Maps) and spending of consumer cell i on producer cell j, conditional on consumer and producer cell fixed effects,

$$\log \text{ flow}_{i \to j} = \alpha_i + \delta_j + \beta \times \log \text{ distance}_{ij} + \epsilon_{ij}. \quad (2)$$

The fixed effects control for all cell-specific factors that determine total spending out of or into a cell, such as population size, average income, or industry. Panel a of Figure IV shows a binned scatter plot and Table A.III the associated regression table. The relation between spending and distance is negative and close to linear, with a gradient of -1.5. Panel b shows that there is significant heterogeneity depending on the types of goods purchased. Spending on fuel and groceries, which often involves in-person shopping trips and card payments, decreases steeply with distance, consistent with findings on card spending in Agarwal et al. (2020). Spending on telecommunications, insurance, and financial services, which is often done remotely via bank or bill transfers, and spending on hotels and rental cars, which is often part of travel, still declines with distance but less steeply.

We also estimate gravity relations for other flows. Labor compensation displays an average distance gradient close to that of consumer spending, partly because consumers shop where they work (see Figures A.VI and A.VII). The labor compensation gradient is less linear and especially steep in the middle distance range (Monte et al. 2018). Trade in intermediate inputs declines less with distance, as the average distance coefficient in the CrediWire data is -0.6. The distance coefficient for mixed plus surplus income is low, which is mainly driven by a coefficient close to zero for corporate surplus payments (i.e., the large distance between stock owners and corporate producers).

V.B Consumer Spending Flows Toward Urban Regions

Figure III already illustrated that cities attract a large share of spending. We next show that spending systematically flows to more urban regions. We use population size to identify more urban regions, but results are similar when we use density. Figure Va plots the average log population of producer cells (which receive spending) for bins of consumer cell log population. Almost all points lie above the 45 degree line, indicating that consumers tend to spend in regions that are more urban than their home region.

There is substantial heterogeneity by receiving industry, as exemplified in Figure Vb. Consumers mostly purchase groceries in their home region, implying that the line for groceries is close to the 45 degree line. In contrast, spending on telecommunication services and insurance on average flows to the most urban locations, implying a flatter line above the 45 degree line. We find similar patterns when we compare spending on all industries in Figure A.IX to only in-person spending in Figure A.X.

The flow of spending toward more urban regions represents a statistically and economically significant deviation from the standard gravity equation. We explore this with a specification that interacts distance with the population size of the destination of spending,

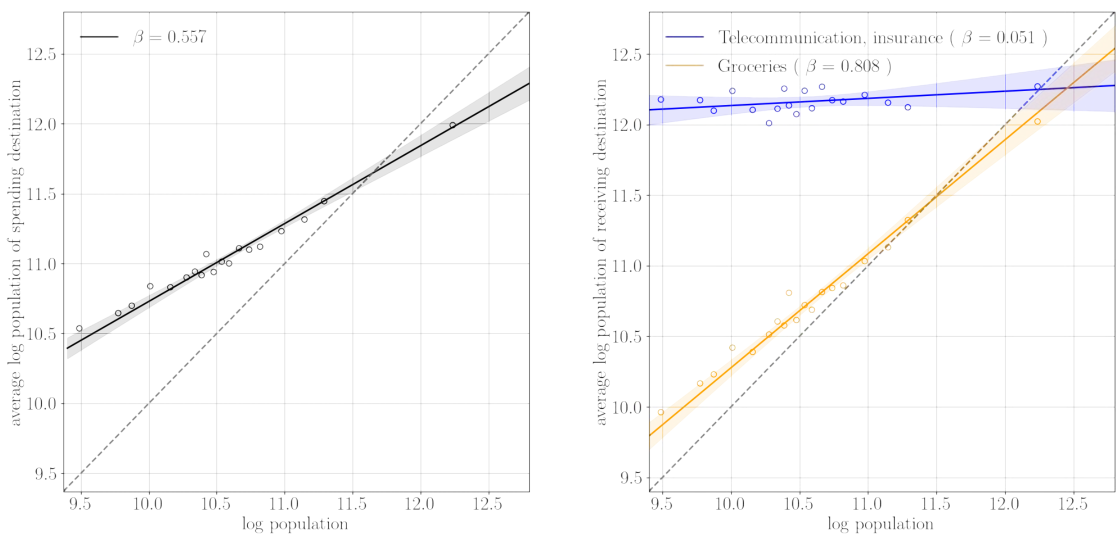
$$\log \text{flow}_{i \to j} = \alpha_i + \delta_j + \beta \times \log \text{distance}_{ij} + \gamma \times \log \text{distance}_{ij} \times \log \text{size}_j + \epsilon_{ij}. \quad (3)$$

Table II shows that spending flowing into large regions is less sensitive to distance (column 2). This result implies that consumers from near and far tend to spend in urban regions, whereas spending on rural establishments is more likely to come from nearby consumers.

Figure V: Population of home and receiving region

(a) All industries

(b) Only telecommunications and groceries



Notes: The panels show average log population of regions receiving consumer spending (vertical axis) for 20 evenly sized bins of consumers' home region log population (horizontal axis). We include only spending to Danish producers in the calculations. The solid line is the line of best fit, estimated using the cell-level data. The shaded areas represent 95% robust confidence intervals.

Table II: Gravity regressions with interactions

	log spending	
	(1)	*(2)*
log distance	−1.463***	−1.782***
	(0.028)	(0.119)
log distance × log dest. pop.		0.573***
		(0.209)
Origin FE	Yes	Yes
Destination FE	Yes	Yes
Observations	2561036	2561036
R^2	0.332	0.333
F stat.	1268558.6	637240.1

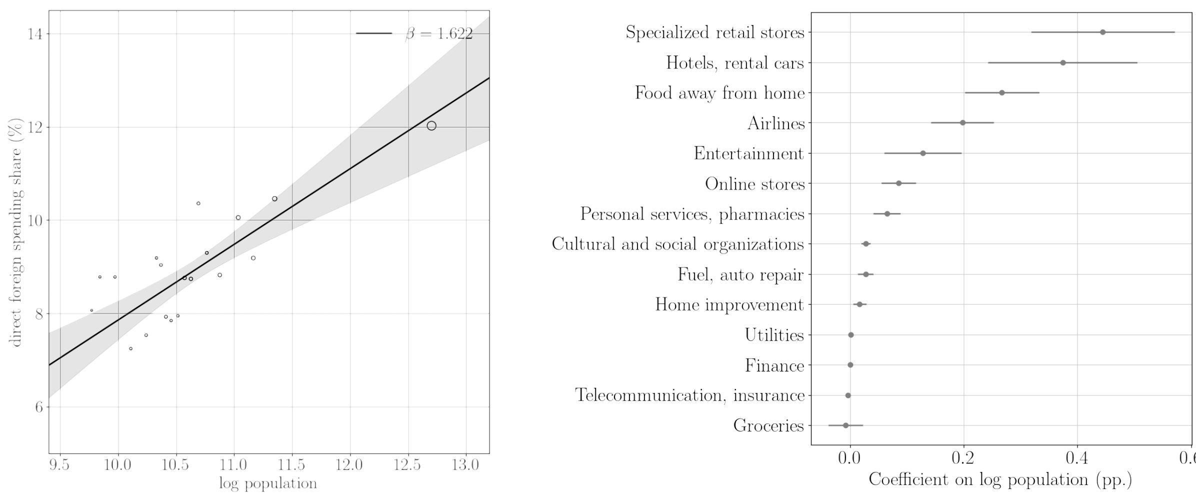
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Notes: Distance is measured as driving distance on Google Maps between region centers. For the interaction terms, we normalize log population to range from 0 to 1 across regions. The interaction coefficient therefore shows the change in the distance gradient when moving from lowest to highest population size. We include only spending to Danish producers in the regressions. Standard errors are two-way clustered by origin and destination cell.

Overall, the fact that consumers spend disproportionately in urban regions is consistent with the hypothesis in Glaeser et al. (2001): cities in advanced economies have become popular places to consume. While Glaeser et al. (2001) emphasize urban migration as a consequence, our findings

Figure VI: Foreign spending by population size

(a) All industries (b) By industry



Notes: Panel a shows the direct foreign spending share of consumer cells by their home region's log population. Panel b shows estimates from a regression of direct foreign spending on a given foreign industry (as share of total spending) on log population. Weights are the number of Danske Bank customers in the consumer cell. Coefficients are expressed in percentage points. The error bars are 95% robust confidence intervals.

suggest that even consumers living in rural regions spend in cities. This is especially true for infrequently purchased items, consistent with the idea of "trip chaining," according to which consumers visit multiple establishments on a single trip (Shoag and Veuger 2018; Miyauchi et al. 2022).

V.C Urban Consumers Spend More Abroad

We next document which Danish consumers spend abroad. Figure VIa shows that urban regions spend a larger fraction in foreign countries. The relation is driven by the fact that urban consumers spend more on specialized retail, hotels, rental cars, food away from home, and airlines in foreign countries, as shown in Figure VIb. The findings are robust to controlling for distance to a foreign border (Table A.V).[11]

V.D Rural Regions Export Abroad, Urban Regions Domestically

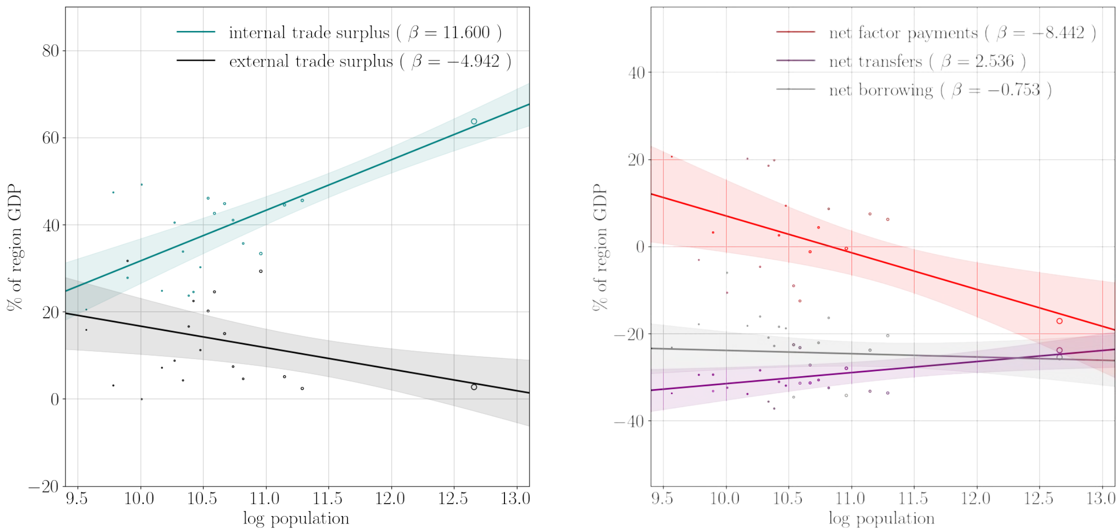
We now investigate all other flows that enter and leave regions. We use our disaggregated accounts to construct comprehensive regional balance of payments (BOP) and GDP statistics. We compute

[11]Figure A.XI documents that consumer cells in high population density regions and with high income also spend more abroad. Figure A.XII shows which foreign industries receive spending by Danish consumers.

Figure VII: Regional balance of payments (normalized by GDP)

(a) External and internal trade surplus

(b) Factor payments, transfers, and borrowing



Notes: The panels show the five components of the regional balance of payments (BOP), normalized by regional GDP. The five components are: external trade surplus (producer exports − producer imports − foreign consumer spending); internal trade surplus (net revenue from sales to domestic producers, domestic consumers, the government, and the capital accumulation cell); net factor payments (net receipts of labor compensation, producer dividends, mixed income, surplus, natural resources rents); net transfers (net receipts of social benefits − payments for taxes and social contributions); net borrowing (negative of interest, transfers, and saving by consumers and producers). The five components add up to zero for each region. Weights are regional GDP. The shaded areas represent 95% robust confidence intervals.

five cross-regional flows, which jointly add up to zero: (i) *external trade surplus*, a region's trade surplus with the rest of the world; (ii) *internal trade surplus*, the trade surplus with the rest of the Danish economy; (iii) *net factor payments*, cross-region payments to labor and capital owners; (iv) *net transfers*, payments from the government less taxes; and (v) *net borrowing*. We compute regional GDP as total production value net of domestic and foreign intermediate purchases.

Figure VIIa shows that external and internal trade surpluses, normalized by regional GDP, vary with regional population. The external trade surplus is largest in rural regions, indicating that rural regions export more of their output to foreign countries. The internal trade surplus, by contrast, is largest in urban regions, indicating that urban regions export more of their output to the rest of Denmark.[12] The pattern of internal trade surplus reflects that domestic consumer spending and domestic intermediate purchases, on net, flow toward urban regions.[13] Figure VIIb

[12]The internal trade surplus does not average out to zero in Panel a because it includes capital accumulation spending and government spending, which are paid for by the capital accumulation and government cells, respectively. Since those two cells do not have a region assigned to them, they do not show up in Panel a.

[13]The external and internal trade surpluses are also larger in more rural regions when not normalized by GDP, as

shows that net factor payments, on average, flow out of urban regions while net government transfers flow into urban regions. Urban regions also have slightly more negative net borrowing, that is, they save more. Taken together, these facts reveal that, on net, money flows from abroad into rural regions and from rural to urban regions.

V.E Government Redistributes Toward Urban Regions

The previous subsection already suggested that government transfers less taxes are, if anything, lower in rural regions. We can use our regional BOP statistics to document more systematically which regions rely more on transactions with the government, relative to regional income. Government spending is responsible for a larger share of income in urban regions (Figure A.XIVa). This is largely due to government spending on healthcare, public administration, education, and cultural institutions (Figure A.XV). Transfers, on the other hand, make up a greater share of income in rural regions, mostly because the share of pensioners is higher in rural regions (Figures A.XVI and A.XVII). There are no large differences in tax revenue generated by urban and rural regions, relative to regional income (Figure A.XIVb). Overall, the effect of government spending dominates: the government redistributes toward urban regions, as the net flows from the government are positive in urban regions and negative in rural regions (Figure A.XVIII).

V.F Stylized Overview: "Triangular Trade"

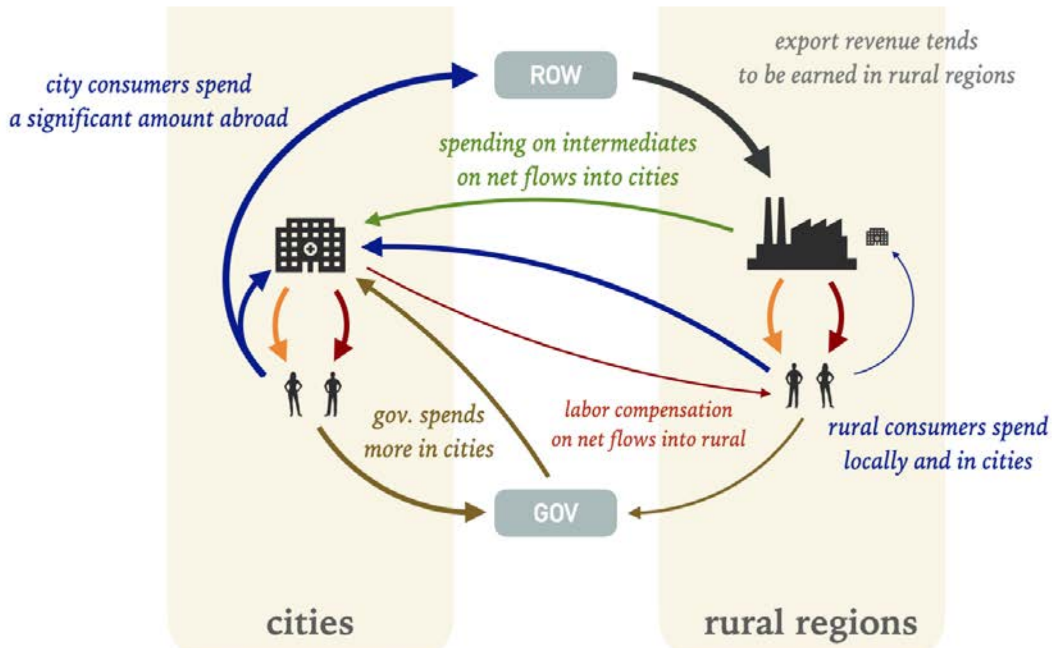
Figure VIII provides a stylized overview of the facts we have documented. Money flows across space in a triangular pattern: from abroad into rural regions, then into urban regions, and finally out of urban regions back abroad. Export revenue is largest in rural regions where it contributes to rural consumers' income. On net, consumer spending leaves rural regions toward urban regions where it contributes to the income of urban consumers. Similarly, spending on intermediate goods on net flows toward urban regions. In turn, urban consumers spend a relatively large share of income abroad. The government transfers income to rural consumers but spends on urban industries, so that, on net, government money flows into urban regions.

VI A Model of Disaggregated Economics Accounts

We have so far measured disaggregated economic accounts and uncovered facts about connections between different parts of the economy. Next, we study whether disaggregated economic accounts

shown in Tables A.VII and A.VIII. See Figure A.XIII for decompositions of the internal and external trade surpluses by industry. They highlight that both are mostly driven by services, such as telecommunications, finance, shipping, and personal services.

Figure VIII: "Triangular trade" pattern of the disaggregated circular flow



improve our understanding of the aggregate and distributional effects of shocks and policy changes. To this end, we develop a model that is as conventional as possible (i.e., the baseline model is fully neoclassical) but allows for heterogeneous consumer and producer cells. This model can then be calibrated using the measured disaggregated economic accounts.

VI.A Overview

We model a small open economy composed of region-by-industry consumer and producer cells, which are linked via consumer spending, factor payments to labor and capital owners, and trade in intermediate goods. The region-by-industry cells also transact with the government and the rest of the world. The model builds on seminal existing work, among others by Acemoglu et al. (2012), Caliendo and Parro (2015), and Baqaee and Farhi (2019b). It is supposed to capture the medium-run behavior of an economy. Because we focus on medium-run effects, the model is static, abstracts from nominal rigidities for now, and does not include a capital accumulation cell (i.e., no saving and investment). We leave a dynamic extension of the model to future work.

There exists a set $\mathcal{I}$ of consumer cells (indexed by $i \in \mathcal{I}$) and a set $\mathcal{J}$ of producer cells (indexed by $j \in \mathcal{J}$). The (large) representative consumer who populates the rest of the world is labeled $i = \mathcal{R} \notin \mathcal{I}$ and the foreign representative producer is $j = \mathcal{R} \notin \mathcal{J}$. We write $\mathcal{I} \cup \{\mathcal{R}\}$ and $\mathcal{J} \cup \{\mathcal{R}\}$ whenever the rest of the world is included in the set of indices. Each cell belongs to an industry s, which is an element of the set $\mathcal{S}_\mathcal{I}$ for consumers and the set $\mathcal{S}_\mathcal{J}$ for producers. We denote by $s(i)$

and $s(j)$ the industries associated with cells i and j, respectively. We use the price level of goods produced by the rest of the world as numeraire and denote all prices and wages in those units. This is not only convenient but also realistic for the Danish economy, which effectively operates a fixed exchange rate against the Euro.

VI.B Setup

We describe consumer and producer cells in turn.

Consumer cells: utility. A finite mass of consumers lives within each consumer cell i, all sharing the same preferences and maximizing utility over consolidated private consumption C_i and consumption of government-provided services G_i,

$$U_i = \log C_i + \psi_i \log G_i = \alpha_{i\mathcal{R}} \log c_{i\mathcal{R}} + (1 - \alpha_{i\mathcal{R}}) \sum_{s \in \mathcal{S}_{\mathcal{J}}} \alpha_{is} \log \left(\sum_{j:s(j)=s} \alpha_{isj}^{\frac{1}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} + \psi_i \log G_i, \tag{4}$$

where $\sum_{s \in \mathcal{S}_{\mathcal{J}}} \alpha_{is} = \sum_{j:s(j)=s} \alpha_{isj} = 1$, and $\psi_i > 0$. $c_{i\mathcal{R}}$ is consumer cell i's consumption of foreign goods and c_{ij} is consumer cell i's consumption of goods produced in producer cell j. Equation (4) describes a nested CES utility function, with a Cobb-Douglas specification across industries and a CES specification with elasticity $\sigma > 0$ within industries.

Consumer cells: labor supply. Consumer industries $\mathcal{S}_{\mathcal{I}}$ are of two types: work industries or non-work industries (listed in Table A.I). If consumer cell i is in a work industry, it has a total labor endowment of N_i, for which it earns a wage W_i. Total labor income is then $N_i W_i$. Consumer cells in non-work industries do not supply labor.

Consumer cells: budget constraint. In addition to labor income, consumer cells earn profit income $\sum_{j \in \mathcal{J}} \kappa_{ij} \Pi_j$. The total profit of producer cell j is Π_j. The share of producer cell j's profits earned by consumer cell i is $\kappa_{ij} \in [0, 1]$. Further, consumer cell i pays a proportional income tax rate τ_i, a domestic product tax τ_i^{vat}, and receives a government transfer T_i. Total nominal pre-tax income of consumer cell i is therefore

$$Y_i = N_i W_i + \sum_{j \in \mathcal{J}} \kappa_{ij} \Pi_j + T_i. \tag{5}$$

The consolidated budget constraint of cell i is then

$$\sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} \left(1+\tau_i^{vat}\right) P_j c_{ij} \leq \left(1-\tau_i\right) Y_i. \tag{6}$$

Producer cells. There is a representative firm in each producer cell $j \in \mathcal{J}$. It produces quantity Q_j of its good j with technology

$$Q_j = Z_j \left(\sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} \lambda_{ij}^{\frac{1}{\zeta}} N_{ij}^{\frac{\zeta-1}{\zeta}} \right)^{\frac{\zeta}{\zeta-1}\gamma_j^N} \prod_{s\in\mathcal{S}_\mathcal{J}} \left(\sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}:s(j')=s} \omega_{jsj'}^{\frac{1}{\eta}} X_{j'j}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}\omega_{js}\gamma_j^X}, \tag{7}$$

where $\sum_s \omega_{js} = \sum_{j':s(j')=s} \omega_{jsj'} = \sum_i \lambda_{ij} = 1$. Producer cell j uses N_{ij} units of labor supplied by consumer cell i in the same industry, $s(i) = s(j)$, with total j-specific labor income share γ_j^N.[14] The elasticity of substitution between labor supplied by different consumer cells is $\zeta > 0$. Cell j uses $X_{j'j}$ units of intermediate goods, purchased from firm cell j', for each $j' \in \mathcal{J} \cup \{\mathcal{R}\}$. The elasticity of substitution between producer cells in the same industry is $\eta > 0$. Total factor productivity is given by Z_j. We assume weakly decreasing returns to scale, $\gamma_j^N + \gamma_j^X \leq 1$, allowing for potentially fixed factors. Pretax profits are

$$\Pi_j^{pre} = P_j Q_j - \sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} W_i N_{ij} - \sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} P_{j'} X_{j'j}. \tag{8}$$

We think of profits as remuneration for a "fixed factor" that causes the production function (7) to have decreasing returns to scale. Profits are taxed at the corporate tax rate $\tau_j^{corp} \geq 0$. After-tax profits are then

$$\Pi_j = \left(1-\tau_j^{corp}\right) \Pi_j^{pre}. \tag{9}$$

Rest of the world. Domestic consumers and producers buy foreign goods at exogenous price $P_\mathcal{R}$. Export demand for domestically produced goods is

$$x_j = \tilde{x}_j \cdot P_j^{-\tilde{\sigma}}, \tag{10}$$

where the elasticity of exports to the terms of trade is equal to $\tilde{\sigma} > 0$ and $\tilde{x}_j$ is a shifter for the rest of the world's preference for good j. The rest of the world also demands domestic labor,

$$N_{i\mathcal{R}} = \tilde{N}_{i\mathcal{R}} \cdot W_i^{-\tilde{\zeta}}, \tag{11}$$

[14] We set $\lambda_{ij} = 0$ if $s(i) \neq s(j)$. i is also allowed to be the rest of the world.

where $\tilde{\zeta} > 0$ is a labor demand elasticity. The current account is balanced in equilibrium,

$$\underbrace{\sum_{j\in\mathcal{J}} P_j x_j}_{\text{exports}} + \underbrace{\sum_{i\in\mathcal{I}} W_i N_{i\mathcal{R}} - \sum_{j\in\mathcal{J}} W_{\mathcal{R}} N_{\mathcal{R}j}}_{\text{net factor payments}} = \underbrace{\sum_{i\in\mathcal{I}} P_{\mathcal{R}} c_{i\mathcal{R}} + P_{\mathcal{R}} G_{\mathcal{R}} + \sum_{j\in\mathcal{J}} P_{\mathcal{R}} X_{\mathcal{R}j}}_{\text{imports}}.$$

Government. The government pays (nominal) transfers T_i, spends on domestically produced goods G_j, and imports goods $G_{\mathcal{R}}$, all financed by tax revenue. The government budget constraint is

$$\sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j G_j + \sum_{i\in\mathcal{I}} T_i = \sum_{i\in\mathcal{I}} \tau_i Y_i + \sum_{j\in\mathcal{J}} \tau_j^{corp} \Pi_j^{pre} + \sum_{i\in\mathcal{I}} \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} \tau_i^{vat} P_j c_{ij}. \tag{12}$$

We assume that the government follows a fiscal rule that adjusts government purchases and transfers in line with revenues, that is,

$$P_j G_j = g_j \cdot \left(\sum_{i\in\mathcal{I}} \tau_i Y_i + \sum_{j\in\mathcal{J}} \tau_j^{corp} \Pi_j^{pre} + \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} \tau_i^{vat} P_j c_{ij} \right)$$
$$T_i = t_i \cdot \left(\sum_{i\in\mathcal{I}} \tau_i Y_i + \sum_{j\in\mathcal{J}} \tau_j^{corp} \Pi_j^{pre} + \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} \tau_i^{vat} P_j c_{ij} \right),$$

such that $\sum_j g_j + \sum_i t_i = 1$. We vary the fiscal rule in Section VIII.B.

We assume further that goods purchased by the government maximize a homothetic aggregator $v(\{G_j\})$, with price index $\mathcal{P}(\{P_j\})$, of which consumer cell i consumes a fixed share ν_i, $G_i = \nu_i \cdot v(\{G_j\})$.[15] The weight ψ_i on consumer cell i's consumption of government output is consistent with the Samuelson (1954) condition for government spending,

$$\psi_i = \nu_i \cdot \left(\sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j G_j \right) / \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j c_{ij}.$$

Equilibrium. We define equilibrium as in any competitive model with flexible prices.

Definition 1. A *competitive equilibrium* in the economy consists of prices and wages $\{P_j, W_i\}$ and an allocation $\{Q_j, N_{ij}, X_{j'j}, \Pi_j, T_i, G_j, Y_i, c_{ij}, x_j\}$ such that (a) income is given by (5); (b) all consumer cells maximize utility (4) subject to (6); (c) all producer cells maximize profits (9); (d) the government's budget (12) is balanced; (e) foreign goods and labor demands (10) and (11) hold; (f)

[15] The exact functional form of v will not affect our analysis.

labor markets clear for each consumer cell,

$$N_i = \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} N_{ij}; \tag{13}$$

(g) the goods market clears for each producer cell,

$$Q_j = \sum_{j' \in \mathcal{J}} X_{jj'} + x_j + \sum_{i \in \mathcal{I}} c_{ij} + G_j; \tag{14}$$

and (h) the current account is balanced, (11).

VI.C Calibration with Disaggregated Economic Accounts

We calibrate the model to match the disaggregated economic accounts measured in Section IV, as summarized in Table A.IX. For the baseline calibrated equilibrium, we normalize all prices and wages to 1, that is, $P_j = W_i = P_{\mathcal{R}} = W_{\mathcal{R}} = 1$. This is without loss since (a) the units of production can always be chosen to set $P_j = 1$ (by choosing Z_j) and (b) the units of labor supply can always be chosen to obtain $W_i = 1$ (by choosing N_i).[16] With this normalization, the average spending share of consumer cell i on producer cell j is

$$\frac{P_j c_{ij}}{\sum_j P_j c_{ij}} = \begin{cases} \alpha_{i\mathcal{R}} & \text{if } j = \mathcal{R} \\ (1 - \alpha_{i\mathcal{R}})\, \alpha_{is} \alpha_{isj} & \text{if } j \neq \mathcal{R} \end{cases}.$$

We calibrate the average spending shares $\alpha_{i\mathcal{R}}, \alpha_{is}, \alpha_{isj}$ of consumer cell i to match the corresponding disaggregated consumer spending shares (domestic and foreign spending).

Similarly, we measure the share of producer cell j's wage bill going to consumer cell i, $\frac{N_{ij} W_i}{\sum_i N_{ij} W_i} = \lambda_{ij}$, in the disaggregated labor compensation flows. The distribution of profit income κ_{ij} is calibrated by matching, for each producer cell j, the distribution of dividend, mixed income, and owner-occupied housing surplus across consumer cells. We calibrate τ_i to match the ratio of consumer non-product taxes and social contributions to total income for each consumer cell i; and τ_i^{vat} to match the ratio of consumer product taxes to post-tax consumer cell income. We calibrate τ_j^{corp} to match, as a fraction of j's pre-tax profits Π_j^{pre}, the sum of: dividends and surplus paid to the government, producer product and non-product taxes paid, less subsidies.

We choose cell-level government transfer shares t_i to match social benefits received by i plus adjustments for pension entitlements. We choose government spending shares $g_j, j \in \mathcal{J} \cup \{\mathcal{R}\}$ to match government final consumption expenditure on producer cell j and government imports.

[16]Note that prices and wages will change in our comparative statics results below. These are mere normalizations and do not represent rigidities.

We set the labor share γ_j^N in line with the ratio of labor compensation paid by producer cell j to output by producer cell j, and γ_j^X in line with the ratio of intermediate input purchases to output. We set intermediate input shares $\omega_{js}\omega_{jsj'} = \frac{P_{j'}X_{j'j}}{\sum_{j'} P_{j'}X_{j'j}}$ in line with the disaggregated intermediates trade flows. We choose the relative magnitudes of $\tilde{x}_j$ to match the distribution of exports across producer cells j. We choose the level of $\tilde{x}_j$ to match aggregate GDP.

The calibrated model closely matches the Danish disaggregated economic accounts. The only major difference is the absence of a capital accumulation cell in the model. In Figure A.XIX, we compare the measured values to the model's calibrated steady state. The correlation between model and data is close to 1 both for producer sales as well as for domestic consumer spending, with a residual sum of squares of only 3%.

The only parameters that cannot be directly calibrated from the disaggregated accounts are the elasticities $\sigma, \tilde{\sigma}, \zeta, \tilde{\zeta}$, and η. These elasticities are typically assumed to be small in the short run, often below 1 (e.g., Baqaee and Farhi 2022a; Gourinchas et al. 2021; Boehm et al. 2023) and large in the long run. Our baseline choice is Cobb-Douglas, $\sigma = \tilde{\sigma} = \zeta = \tilde{\zeta} = \eta = 1$, which will make our theoretical results below tractable. We show in Section VIII.D that the results are quantitatively similar for $\sigma = \tilde{\sigma} = \zeta = \tilde{\zeta} = \eta = 2$.

VII Insights about the Aggregate Implications of Fiscal Policy

We view the model, calibrated using the disaggregated economic accounts (DEA), as a general tool that allows us to understand the propagation of a range of shocks and policies. In two specific applications, we now highlight how the calibrated model helps us understand the welfare effects of fiscal policy (Section VII) and the gains from trade (Section VIII). In both applications, we compare the results from the DEA-consistent model with results from a model without disaggregated consumers and a model with the "Stone National Accounts" recommended by the UN SNA.

VII.A Aggregate Welfare and Real GDP

In the first application, we study the effects of fiscal transfers on aggregate welfare. We define aggregate welfare as the inverse marginal utility weighted sum of U_i in (4). This measure ignores redistributive concerns. In fact, its first-order change equals the marginal change in the economy's real gross national expenditure (GNE, see Appendix R.A),

$$dGNE \equiv \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} P_j dG_j + \sum_{i \in \mathcal{I}} \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} P_j dc_{ij}. \tag{15}$$

We also study the effects of fiscal transfers on GDP, though this is not our primary focus. There, we follow the standard definition of changes in real GDP (e.g., Baqaee and Farhi 2019b),

$$dGDP \equiv \sum_{j\in\mathcal{J}} P_j dQ_j - \sum_{j\in\mathcal{J}} \sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} P_{j'} dX_{j'j}.$$

The fiscal transfer shocks that we consider are small changes dT_i in government transfers to consumer cell i. We are interested in the effects of fiscal transfers alone, so we assume, for now, that dT_i is funded by a transfer to the government from the rest of the world. For each consumer cell i, we compute the welfare (or output) effect of the transfer divided by 1 minus the percentage $\overline{\tau}_i$ of the transfer that is recouped by the government via greater tax revenue. This gives welfare and output multipliers,

$$\mu_i^{\text{welfare}} \equiv \frac{dGNE}{(1-\overline{\tau}_i)\, dT_i} \qquad \mu_i^{\text{output}} \equiv \frac{dGDP}{(1-\overline{\tau}_i)\, dT_i},$$

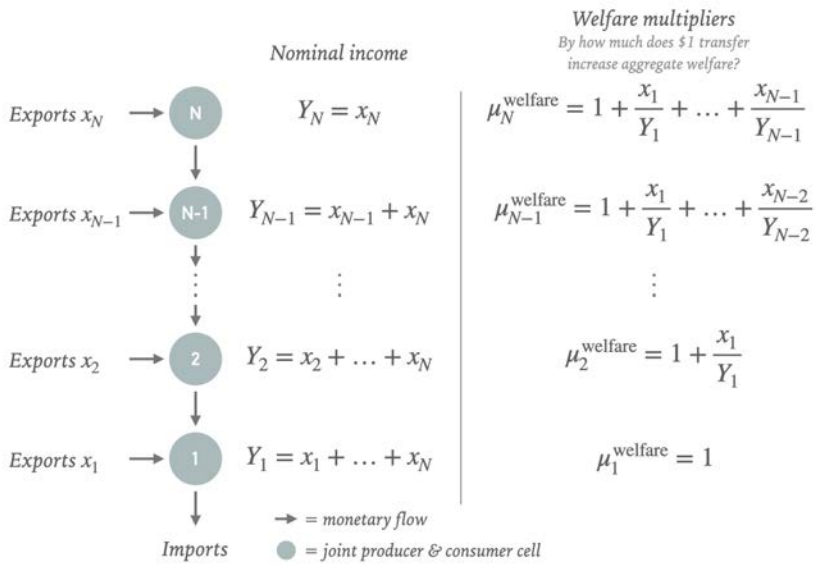
where μ_i^{welfare} is the increase in welfare (in units of real GNE) due to the transfer shock divided by the actual outlays of the government. In public economics, μ_i^{welfare} is also known as the "marginal value of public funds" (e.g., Hendren and Sprung-Keyser 2020). Similarly, μ_i^{output} measures the real GDP increase due to the transfer shock.

One may wonder whether Hulten's (1978) theorem implies that μ_i^{welfare} should always be 1. After all, the calibrated model is a neoclassical, frictionless economy and dT_i is effectively a transfer from the rest of the world. However, we show next that this conclusion would be incorrect. Instead, there is substantial heterogeneity in μ_i^{welfare} across cells, driven by the position of cell i in the disaggregated circular flow of money.

VII.B Conceptual Example of a Vertical Circular Flow

We begin with a special case of our model to gain intuition for how a consumer cell's position in the circular flow determines its welfare multiplier μ_i^{welfare}. The special case is the vertical circular flow illustrated in Figure IX, where the direction of the arrows indicates the direction of financial flows. This vertical economy consists of N consumer and producer cells, labeled $i = 1, \ldots, N$. Each producer cell i converts labor supplied by consumer cell i into output. Figure IX plots the economy by combining the corresponding producer and consumer cells into a single "consumer-producer" cell i. In general, cell i exports x_i to the rest of the world and may also sell domestically to cell $i+1$, for $i < N$. The top cell $i = N$ exports to the rest of the world, does not sell domestically, and buys domestically from cell $i = N-1$. The bottom cell $i = 1$ exports, sells domestically to cell $i = 2$, and buys only from the rest of the world. In terms of monetary flows, cell $i = 1$ is the most

Figure IX: Welfare multipliers in the vertical circular flow



"downstream" cell, while cell $i = N$ is the most "upstream" cell. There are no taxes, so $\overline{\tau}_i = 0$.

If there is only a single cell, $N = 1$, the multiplier is $\mu_1^{\text{welfare}} = 1$, as consumption increases one-to-one with the transfer shock, so $dC_1 = dT_1$. With two cells, $N = 2$, a transfer to the downstream cell $i = 1$ still has a unit multiplier, $\mu_1^{\text{welfare}} = 1$, as $dC_1 = dT_1$ again. However, a transfer to cell $i = 2$ no longer has a unit multiplier. As the transfer stimulates additional nominal demand for good 1, $dY_1 = dT_2$, it pushes up the price P_1. For market clearing, $d(P_1 Q_1) = dY_1$ needs to hold. Moreover, since good 1 is produced inelastically, $dQ_1 = 0$ needs to hold. Thus, price 1 increases by

$$d \log P_1 = \frac{dY_1}{Y_1} = \frac{dT_2}{Y_1}. \tag{16}$$

Considering the price increase, consumers in cell $i = 2$ only benefit, in real terms, by $dC_2 = dT_2 - C_2 d \log P_1 = \frac{x_1}{Y_1} dT_2$. Consumers in cell $i = 1$, on the other hand, still receive an increase of dT_2 in their income, which they spend abroad, $dC_1 = dT_2$. The welfare multiplier for a transfer to cell 2 is thus given by

$$\mu_2^{\text{welfare}} = \frac{dC_1}{dT_2} + \frac{dC_2}{dT_2} = 1 + \frac{x_1}{Y_1}.$$

This result highlights that the welfare multiplier can exceed 1 when transfers propagate through multiple consumers cells. The multiplier above 1 is due to a pecuniary externality: the price of good 1 rises, which partially crowds out exports x_1. While this does not change welfare at the world level (pecuniary externalities still net out), it benefits domestic consumers at the expense of foreign consumers. As a result, $\mu_2^{\text{welfare}} > 1$.[17]

We can generalize this intuition for a vertical circular flow of arbitrary length.

Proposition 1. *In the vertical flow economy, the welfare multiplier (marginal value of public funds) for producer cell i is*

$$\mu_i^{\textit{welfare}} = 1 + \frac{x_1}{Y_1} + \ldots + \frac{x_{i-1}}{Y_{i-1}}. \quad (17)$$

Proposition 1 highlights a crucial relation between the welfare multiplier associated with a cell and the cell's position in the disaggregated circular flow: the longer a transfer circulates domestically (i.e., the more often it is spent), the greater the multiplier. Under the simplifying assumption that export ratios x/Y are identical for all producers $i < N$, we find that $\mu_i^{\text{welfare}} = 1 + (i-1) \cdot x/Y$ for $i < N$, directly relating "upstreamness" i, a cell's position in the circular flow, to the multiplier associated with cell i.

Role of disaggregated consumer spending. The vertical economy of Figure IX illustrates that we need data on disaggregated consumer spending to understand welfare multipliers. Imagine, for example, that consumer cell i spent only on producer cell i, as shown in Figure X. This would imply an economy with N separate "islands" operating in parallel. Without data on disaggregated consumer spending, this island economy is indistinguishable from the vertical economy in Figure IX. Yet, its welfare multipliers are totally different. For each island i, the multiplier is[18]

$$\mu_i^{\text{welfare}} = \frac{dC_i}{dT_i} = 2 - \frac{x_i}{Y_i}.$$

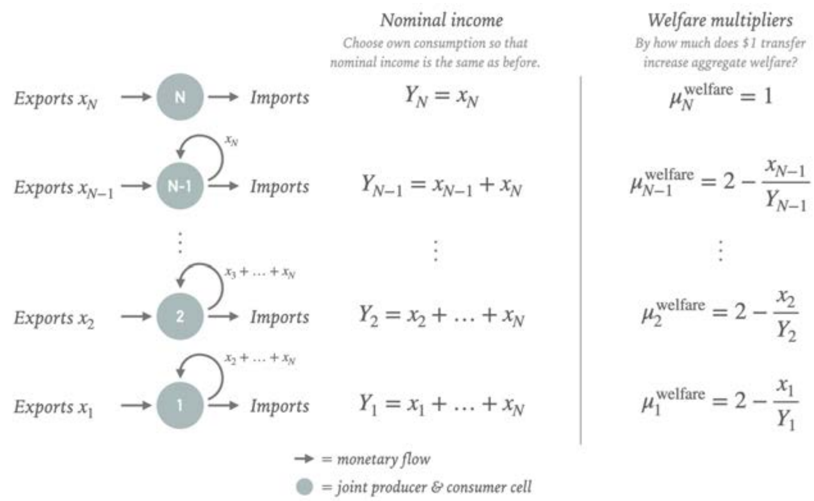
In the special case where x_i/Y_i is identical for $i < N$, the multiplier μ_i^{welfare} is identical for $i < N$ and thus very different from the vertical economy above where $\mu_i^{\text{welfare}} = 1 + i\frac{x}{Y}$ with identical x_i/Y_i. This finding highlights that measuring disaggregated spending flows is crucial for our understanding of welfare multipliers.

Relation to intermediates trade networks. The example of Figure IX does not contain trade in intermediate goods. The heterogeneity in multipliers we document, in the example of Figure IX but also in the other analyses below, is therefore distinct from recent work on production networks. Instead, our analysis relates to recent studies analyzing the propagation of shocks in a

[17]This logic transcends the Cobb-Douglas unitary elasticities. For example, in the case of the vertical circular flow shown in Figure IX, allowing for a greater but finite elasticity of export demand $\tilde{\sigma} > 1$ leads to attenuated multipliers that remain above 1. Vice versa, multipliers increase even further if $\tilde{\sigma} < 1$.

[18]This follows from the fact that (i) consumer i spends a share $\alpha \equiv 1 - x_i/Y_i$ on island i, $dY_i = (1-\alpha)\, dY_i + (1-\alpha)\, dT_i$; (ii) the price response as in (16), $d\log P_i = dY_i/Y_i$; and (iii) $dC_i = dY_i + dT_i - \left(1 - \frac{x_i}{Y_i}\right) Y_i d\log P_i$.

Figure X: Welfare multipliers in an island version of the vertical circular flow



world with consumers in many different regions, such as Caliendo and Parro (2015), Antràs and Chor (2019), Kleinman et al. (2023), and Baqaee and Farhi (2022a). Different from these papers, our focus is on the circular flow of consumer spending between many heterogeneous groups of consumers within a country. We show that the nature of spending flows matters because it determines the welfare effects of fiscal policy.

VII.C Welfare Effects of Fiscal Policy

We move to the full model. As we show in Appendix R.C, we can characterize welfare multipliers similarly to Proposition 1:

Proposition 2. *In the full model, the welfare multiplier (marginal value of public funds) for consumer cell i is*

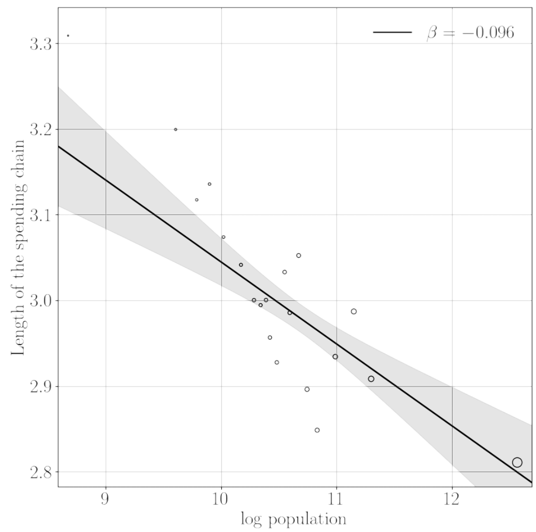
$$\mu_i^{welfare} = 1 + \sum_{i' \in \mathcal{I}} \chi_{i'} \frac{dW_{i'}}{(1-\overline{\tau}_i)\, dT_i} + \sum_{j \in \mathcal{J}} \chi_j \frac{d\Pi_j^{pre}}{(1-\overline{\tau}_i)\, dT_i} \tag{18}$$

where χ_i denotes the network-adjusted export intensity of labor of consumer cell i; χ_j is the network-adjusted export intensity of producer cell j; and $\frac{dW_{i'}}{(1-\overline{\tau}_i)dT_i}$ and $\frac{d\Pi_j^{pre}}{(1-\overline{\tau}_i)dT_i}$ are the exposures of wages and pre-tax profits, respectively, to the transfer.

Proposition 2 shows that the welfare multiplier of a transfer to consumer cell i is equal to a large summation across all factors in the model—all consumer cells' labor and all producer cells' fixed factors. For each factor, the summand consists of a product of the factor's export intensity χ as well as the factor's exposure to the transfer.[19]

[19] This formula echoes Proposition 1. There, $\overline{\tau}_i = 0$, and a transfer to cell i affected labor income of all consumer

Figure XI: Length of the spending chain across rural and urban Denmark



Notes: The length of the spending chain counts how many times, on average, a transfer to a consumer cell is spent by consumer cells or the government within Denmark before leaving the Danish economy. The plot is a binned scatter with 20 bins, across Danish regions, weighted by population.

Just as in the vertical economy, welfare multipliers (18) depend crucially on how long a transfer circulates through the domestic economy before "leaking" to the rest of the world. We define the "length of the spending chain" as the effect of a transfer to consumer cell i on nominal gross national expenditure,[20]

$$\text{Length of the spending chain}_i \equiv \frac{\sum_{i' \in \mathcal{I}} \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} d\left(P_j c_{i'j}\right)}{\left(1 - \overline{\tau}_i\right) dT_i}. \tag{19}$$

The length of the spending chain is a formal measure of the "upstreamness" of a consumer cell or, equivalently, the "economic distance" of that cell to the border. In the vertical economy, the length of the spending chain is simply i. As Figure XI shows, the length of the spending chain in the Danish economy is tightly associated with geography. Rural regions sit at the beginning of longer spending chains than urban regions, in line with the facts from Section V.

Figure XII depicts welfare multipliers in the full, DEA-consistent model and compares them to two alternative models: a model without disaggregated consumer flows (but with region-by-industry producer cells) and a model with the traditional "Stone National Accounts" (with industry-level producer cells as in the UN SNA). Panel a shows the raw distribution of multipliers

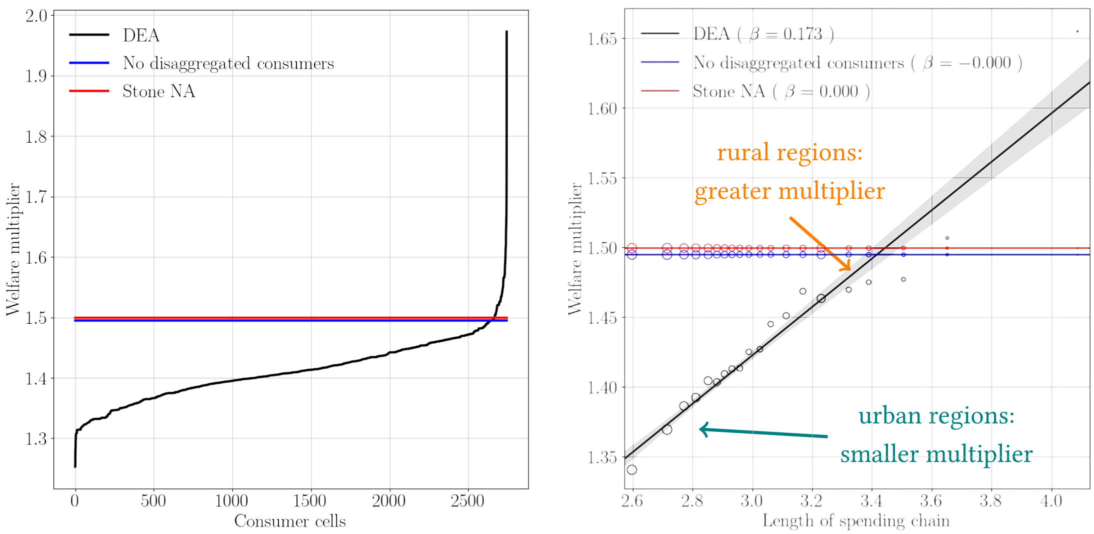
cells $i' = 1, \ldots, i$ one-to-one, $\frac{dW_{i'}}{dT_i} = 1$. Moreover, $\chi_{i'} = \frac{x_i}{Y_i}$, immediately implying that (18) reads $\mu_i^{\text{welfare}} = 1 + \frac{x_1}{Y_1} + \ldots + \frac{x_i}{Y_i}$.

[20] Nominal government spending $P_j G_j$ is unchanged here as the transfer goes to households.

Figure XII: Welfare multipliers in the DEA

(a) Distribution of multipliers

(b) Multipliers by length of spending chain



Notes: Welfare multipliers (or marginal value of public funds) are computed as the marginal aggregate welfare benefit in response to a transfer. Panel a shows the distribution of welfare multipliers across consumers cells, weighted by a consumer cell's population. Panel b shows welfare multipliers by the length of the spending chain (20 bins), weighted by cell population.

across the 2,744 consumer cells (sorted on the horizontal axis according to their multiplier). There is meaningful dispersion in multipliers in the DEA-consistent model. In contrast, all multipliers are equal in the two alternative models. (We discuss the higher average levels of multipliers in the alternative models in Section VII.E).

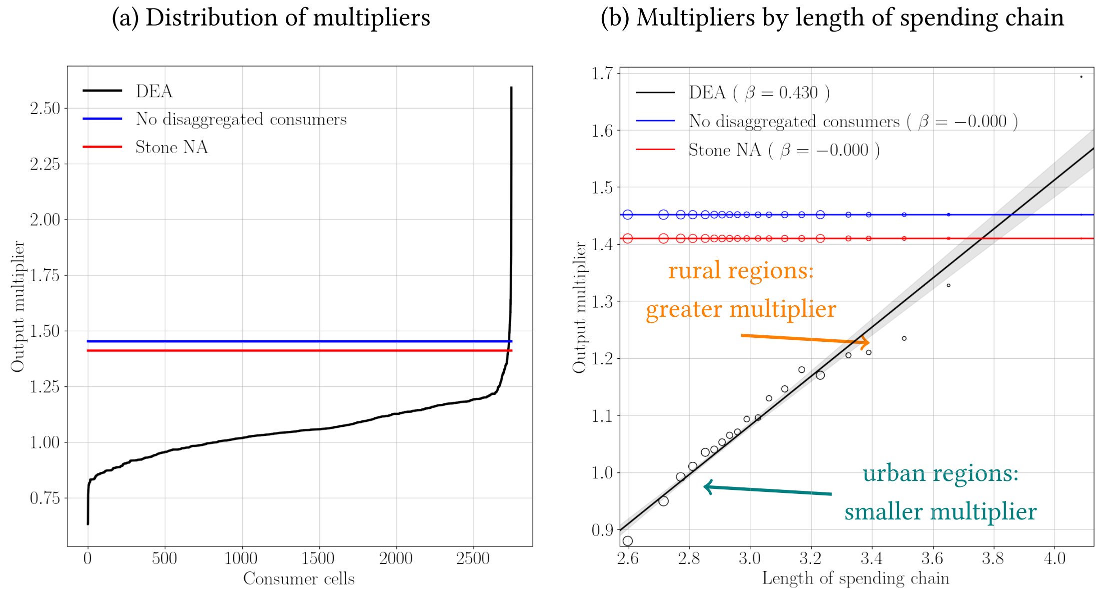
Panel b shows that the length of the spending chain largely drives variation in multipliers. More urban regions (larger circles to the left) have shorter spending chains and therefore smaller welfare multipliers. More rural regions (to the right) have longer spending chains and greater welfare multipliers. The heterogeneity in the length of spending chains is therefore related to the "triangular trade" pattern documented in Section V.

VII.D Output Effects of Fiscal Policy

So far, we have characterized welfare multipliers but not output (real GDP) multipliers. In the neoclassical model studied so far, output multipliers are close to zero because there are no nominal rigidities, implying that Keynesian stimulus effects on output are absent.[21]

[21] In the neoclassical model, output multipliers are only nonzero because of elastic cross-border labor supply $N_{i\mathcal{R}}$ and labor demand $N_{\mathcal{R}j}$. Greater domestic demand can then, on net, increase labor in the Danish economy, raising output. However, since $N_{i\mathcal{R}}$ and $N_{\mathcal{R}j}$ are small relative to output, neoclassical output multipliers are small, too.

Figure XIII: Output multipliers in the DEA



Notes: Output multipliers are computed as the marginal response of aggregate real GDP to a transfer. Panel a shows the distribution of output multipliers across consumers cells, weighted by a consumer cell's population. Panel b shows output multipliers by the length of the spending chain (20 bins), weighted by cell population.

We now extend the model to explore such Keynesian effects. The idea is to develop a proof of concept showcasing how nominal rigidities can lead to heterogeneous output multipliers that depend on the type of consumer targeted by fiscal policy. To do so, we assume that all wages W_i are fixed at the level of the pre-transfer calibrated economy; that workers work additional hours N_i in order to satisfy labor demand, as is common in New-Keynesian models with wage rigidities; and that the nominal exchange rate is pegged, providing a nominal anchor to the domestic economy. We discuss these assumptions in detail in Appendix R.D.

Figure XIII shows the aggregate output multipliers μ_i^{output} of transfers targeted to different consumer cells. There is significant heterogeneity in multipliers, ranging from 0.8 to 1.25 (Panel a). Echoing the results on welfare multipliers, we again find that cells with the largest multipliers are the most "upstream" and have the longest spending chains (Panel b). Cells with larger multipliers are typically in rural regions, whereas multipliers in urban regions are smaller, again consistent with the "triangular trade" pattern. These findings complement recent work on heterogeneity in aggregate output multipliers depending on the labor share of targeted industries (Baqaee 2015), MPC of consumers (e.g., Oh and Reis 2012; Flynn et al. 2021; Kekre 2023), and the degree of deficit financing (e.g., Galí et al. 2007; Farhi and Werning 2016; Bilbiie 2020; Auclert et al. 2023).

VII.E Discussion and Robustness

Role of region-by-industry classification. Our results on multipliers hinge on the relatively fine region-by-industry classification in the disaggregated accounts. Without regional variation, there would be no heterogeneity in multipliers conditional on industry. Without industry variation, we would not obtain the correct patterns of multipliers, as shown in Figure A.XX (blue line).

Industry variation matters for two reasons. First, we would generally overestimate multipliers without industry variation. Export-oriented industries, such as manufacturing and shipping, receive little consumer spending in the disaggregated economic accounts. However, without industry variation, one would incorrectly deduce that substantial consumer spending goes to these industries, which would increase multipliers, as shown in Proposition 2.

Second, multipliers would be flat in the length of the spending chain, as spending spreads more rapidly across regions when all industries, irrespective of their tradability and their intensity in intermediate inputs, are lumped together.

Measurement error. One may worry that measuring disaggregated consumer spending using transaction data induces error, as studied by Dingel and Tintelnot (2021). We find that such potential measurement error does not substantially affect the results in Figure A.XX (red line), where we replace the smallest 90% of consumer spending by imputed values from the standard gravity regression (2).

A separate source of measurement error may be the gravity approximation used to measure disaggregated intermediates trade. The yellow line in Figure A.XX computes multipliers using uniform intermediates trade flows (all producer cells purchase intermediate goods in the same proportions across all other producer cells). Despite the drastic change, the results are similar, underscoring that the results are largely driven by disaggregated consumer spending.

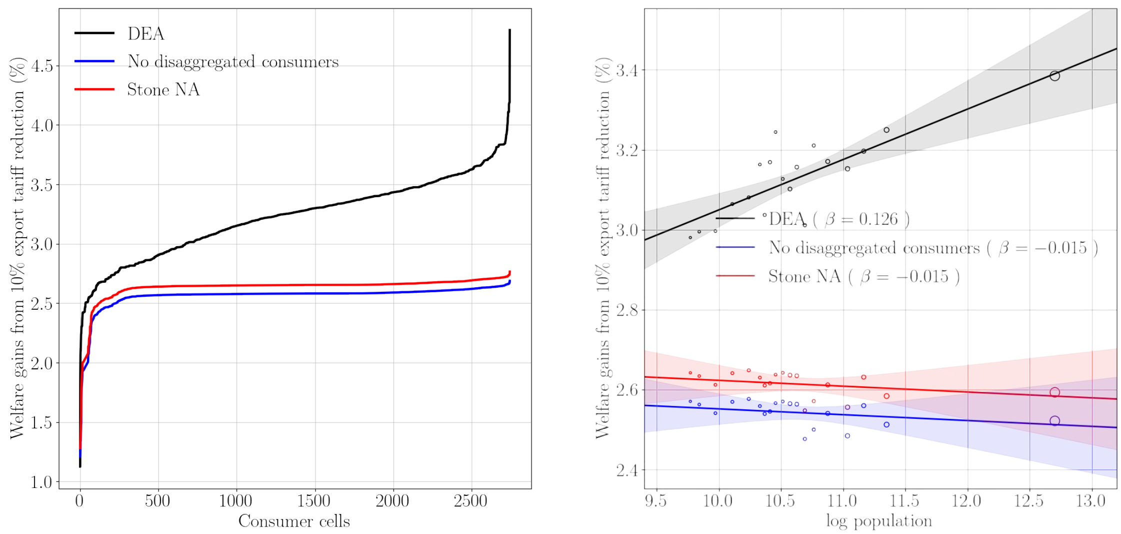
Elasticities. Figure A.XXI shows that the results are similar if we move away from Cobb-Douglas and assume that $\sigma = \tilde{\sigma} = \zeta = \tilde{\zeta} = \eta = 2$.

VIII Insights about the Distributional Effects of Trade

In our second application, we show that disaggregated economic accounts (DEA) affect our understanding of the distributional effects of trade. The trade shock we analyze is a reduction in tariffs on Danish exports, which we model as an increase in export demand shifters $\tilde{x}_j$. Throughout this section, we study how welfare derived from market consumption C_i evolves across different consumer cells i in response to the trade shock.

Figure XIV: Welfare gains from a uniform export demand shock

(a) Distribution of the gains from export demand shocks(b) Gains from export demand shocks by log population



Notes: Panel a shows the distribution of the welfare gains from a 10% increase in export demand due to reduced tariffs, across consumer cells. Panel b plots the same welfare gains in a binned scatter plot with 20 bins across log region population. Shaded areas reflect 95% robust confidence intervals. The plots compare the full DEA model with a model in which consumers are not disaggregated, and with a model in which direct foreign spending is zero and all consumers are assumed to have the same spending pattern. Weights are number of Danske Bank customers per cell.

VIII.A Uniform Trade Shock

We begin our analysis with a uniform reduction in export tariffs. Figure XIV shows the results of a 10% reduction in tariffs, and hence of a 10% increase in demand for all Danish exports. The uniform shock generates large heterogeneity in welfare gains in the DEA-consistent model, as shown in Panel a. Excluding outliers, the gains range from 2.5 to 4 percentage points, a difference of 60 percent.

Panel b illustrates that the welfare gains experienced by consumers in the most urban 20% of regions (with largest population size) are about 20 percent larger than those experienced in the most rural 20%. The distribution of welfare gains across regions is at odds with the direct incidence of export shocks, as rural regions tend to export more (see Section V). Moreover, the difference in gains is large relative to other estimates of the gains from trade (e.g., Borusyak and Jaravel 2021).

The discrepancy between direct and general equilibrium gains is driven by the structure of disaggregated flows. The additional export revenue flowing into rural regions raises rural incomes and prices. The price increases partially offset the income gains, implying that the real consumption gains of rural consumers are lower than the initial income gains. Part of the additional export revenue also flows into urban regions, due to the urban bias of consumer spending and intermediates trade, pushing up urban incomes and prices. Urban consumers benefit from the income gains to a larger extent than rural consumers because urban consumers spend a larger share abroad and foreign prices have not increased. As a result, the real consumption gains of urban consumers are larger than those of rural consumers.

This intuition is reminiscent of the famous Lerner symmetry (see Costinot and Werning 2019 and Barbiero et al. 2019 for modern treatments). While Lerner symmetry does not exactly apply to our model due to cross-border factor payments, it holds approximately. Thus, an increase in export demand due to reduced tariffs has approximately the same welfare consequences as a reduction in import prices, benefiting consumers with a greater share of (direct or indirect) foreign spending.

VIII.B Role of the Government

We explore whether redistribution and spending by the Danish government change the distributional effects of trade. In the DEA-consistent model, the government responds to changes in tax revenue due to exogenous shocks by raising transfers and spending in proportion to their existing distribution across cells. We compare our DEA model to three alternatives: the "transfers only" model, where the government uses all additional revenue to increase transfers; the "spending only" model, where the government uses all additional revenue to increase spending; and the "lower taxes" model, where the government reduces taxes so that its revenue remains stable.[22]

Figure XV highlights that the response of the Danish government is central to distributing the gains from trade. When only transfers are adjusted, rural consumers tend to benefit more; when only spending is adjusted, urban consumers benefit nearly twice as much; when taxes are reduced, effects are more uniform across space.

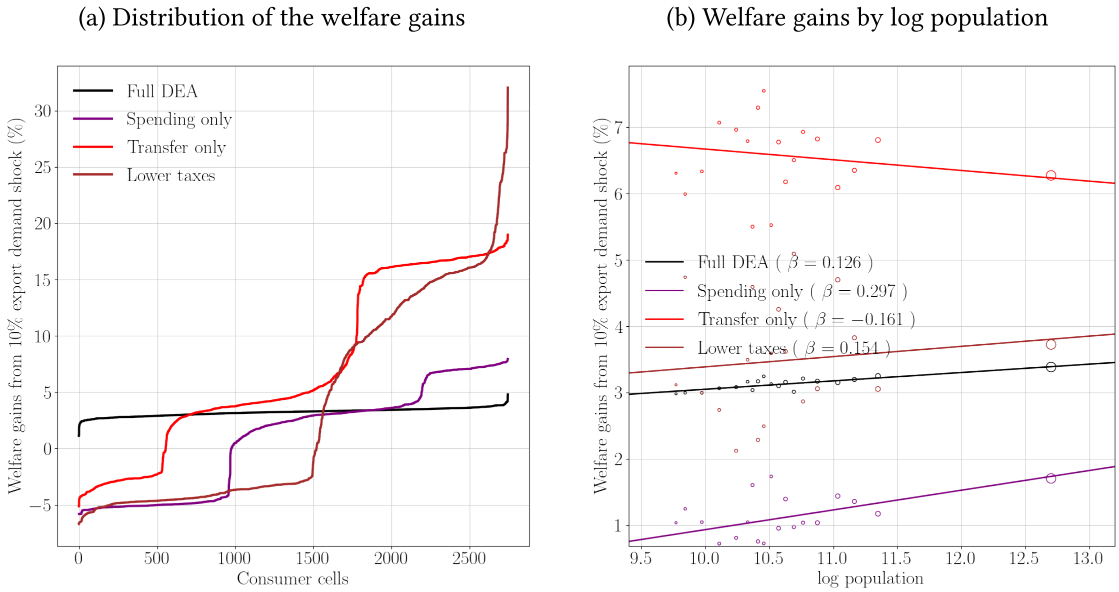
We also find that the government can increase the average gains from trade by adjusting transfers. This is because, as we showed in the previous application, transfers to rural consumers have beneficial effects on aggregate welfare. Vice versa, when spending is adjusted, more resources flow into urban regions, which is less beneficial for aggregate welfare.

VIII.C Industry-Specific Trade Shocks

We next consider industry-specific, rather than uniform, tariff reductions. In Panel a of Figure XVI, we compare a tariff reduction that raises export demand for manufacturing goods by 1% of Danish GDP with one that raises demand for consulting, IT, and media services by 1% of Danish

[22]We assume the adjustment is done separately for each revenue source in (12). For example, if income of consumer cell i increases, we assume that τ_i falls in order to keep $\tau_i Y_i$ unchanged.

Figure XV: Gains from export demand shocks depend on the fiscal response



Notes: Panel a compares the distribution of the welfare gains from a 10% increase in overall export demand across four models: the DEA-consistent model; one in which any government revenue increase is spent; one in which it is used for transfer payments; and one in which taxes are being lowered. Panel b shows a binned scatter plot of welfare gains across log region population. Weights are the number of Danske Bank customers per cell.

GDP. We find that the gains from the manufacturing shock are more equally distributed than the gains from the consulting, IT, and media shock.

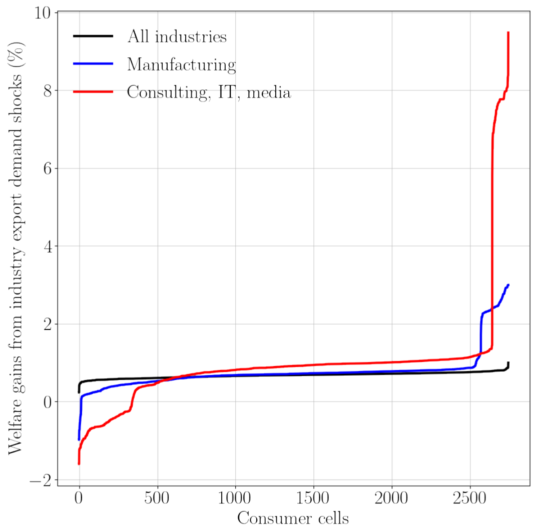
Panel b suggests that the structure of disaggregated flows across regions contributes to this finding. Manufacturing exports are predominantly produced in rural regions, while consulting, IT, and media services are mostly produced in urban regions. Due to the upstream location of manufacturing in the circular flow, its revenues tend to flow downstream toward urban regions, benefiting consumers along the way. In contrast, consulting, IT, and media revenues mostly benefit urban consumers, whose spending bids up prices in cities, hurting consumers of urban-produced services all over Denmark.

VIII.D Discussion and Robustness

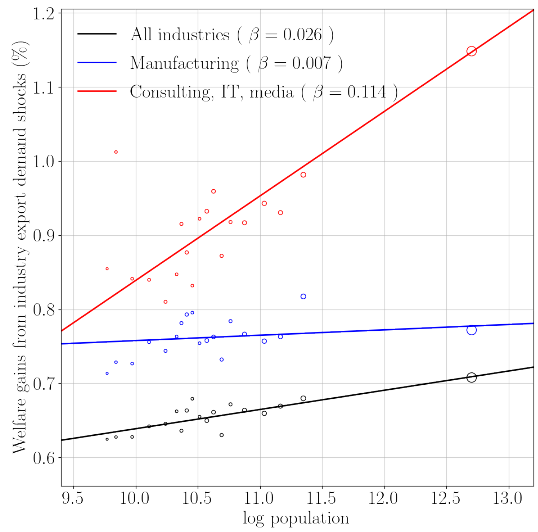
We test whether the results in this section may be due to measurement error, following the methods of Section VII.E. In Figure A.XXII, we replace the smallest 90% of consumer spending flows by values imputed using the standard gravity regression (2) and compute distributional welfare gains from a uniform export demand shock. We find the gains to be similar to the ones in the DEA-consistent model. Figure A.XXIII shows similar distributional gains in two models with alternative disaggregated intermediates trade flows. Finally, the welfare gains derived under

Figure XVI: The distributional gains from industry-specific export shocks

(a) Distribution of the welfare gains



(b) Welfare gains by log population



Notes: Panel a and b compare the distribution and the population gradient of the welfare gains from an increase in exports across two industries: manufacturing as well as consulting, IT, and media. The shock is normalized to 1% of GDP. Weights are the number of Danske Bank customers per cell.

Cobb-Douglas are quantitatively close to the ones derived under a model with larger elasticities, for example to $\sigma = \tilde{\sigma} = \zeta = \tilde{\zeta} = \eta = 2$ in Figure A.XXIV, and to various combinations of other elasticities (e.g., raising η or $\tilde{\sigma}$ to 5 or 6).

IX Conclusion

The idea of a comprehensively disaggregated circular flow of money goes back to at least 18$^{\text{th}}$ century France. Richard Cantillon and François Quesnay envisioned systems of measurement that showed how money cycles across small groups in the economy through consumption, income, and trade links. Conceptual and measurement challenges meant that this idea lay dormant for almost 200 years, until Wassily Leontief developed ways to measure cross-industry trade links and Richard Stone integrated these flows into modern national accounts.

Despite these seminal contributions, the core vision of Cantillon and Quesnay remains unfulfilled. There exists no system of measurement that records flows between small groups of consumers and producers such that: (i) bilateral transactions add up to national aggregates, (ii) accounting identities across different levels of aggregation are satisfied, (iii) rich heterogeneity in bilateral flows across different consumer and producer groups is accurately recorded, and (iv) the full circular flow of consumption, income, and trade links is measured.

The advent of detailed transactions data allows us to take a step toward realizing the vision of a fully disaggregated circular flow. We implement a system of disaggregated economic accounts in Denmark. The new data allow us to present facts on how money circulates across regions and industries. We document, for instance, disproportionate consumer spending flows from rural regions into urban service industries, larger spending abroad by urban consumers, and the role of the government in transferring resources across regions.

We show that these facts have practical bite by combining a disaggregated model with the new data. We find that the aggregate welfare effects of cell-specific fiscal transfers are larger for rural consumers, due to the structure of disaggregated economic accounts. Moreover, we find that the general equilibrium welfare gains from trade are larger for urban consumers, in contrast to the direct incidence of the shocks, because of the urban bias of disaggregated spending flows.

Overall, we underscore that disaggregated economic accounts enrich our understanding of the aggregate and distributional effects of shocks and policies. Given the potential benefits, the system developed in this paper may provide a starting point for similar measurement efforts in other countries.

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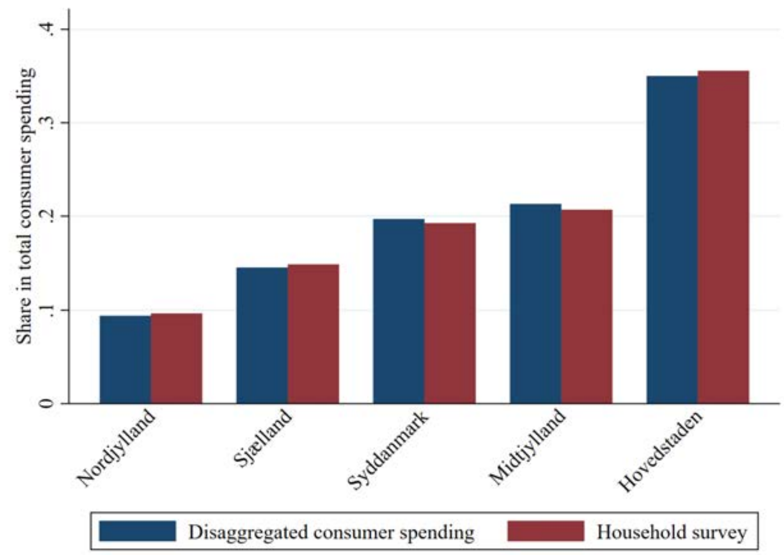
Online Appendix to
Disaggregated Economic Accounts

Appendix Contents

Appendix A Additional Figures and Tables

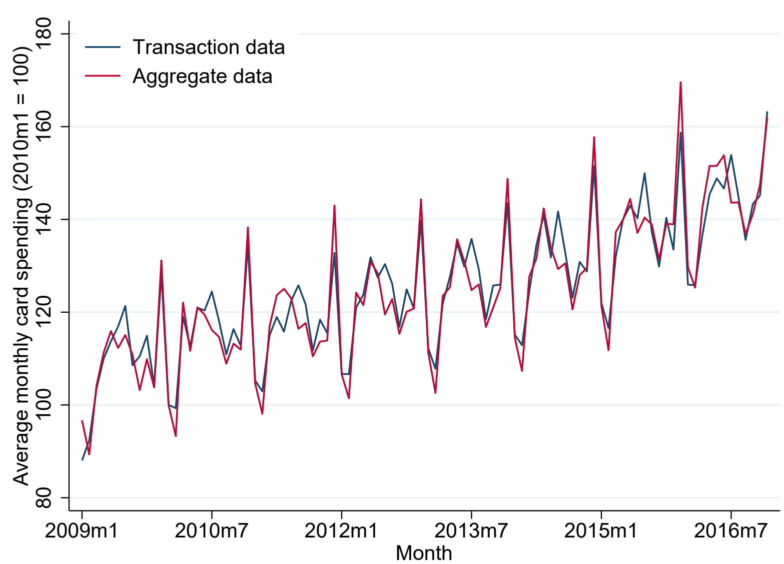
Appendix A.A Measurement

Figure A.I: Spending shares of regions in the disaggregated spending flows and household survey



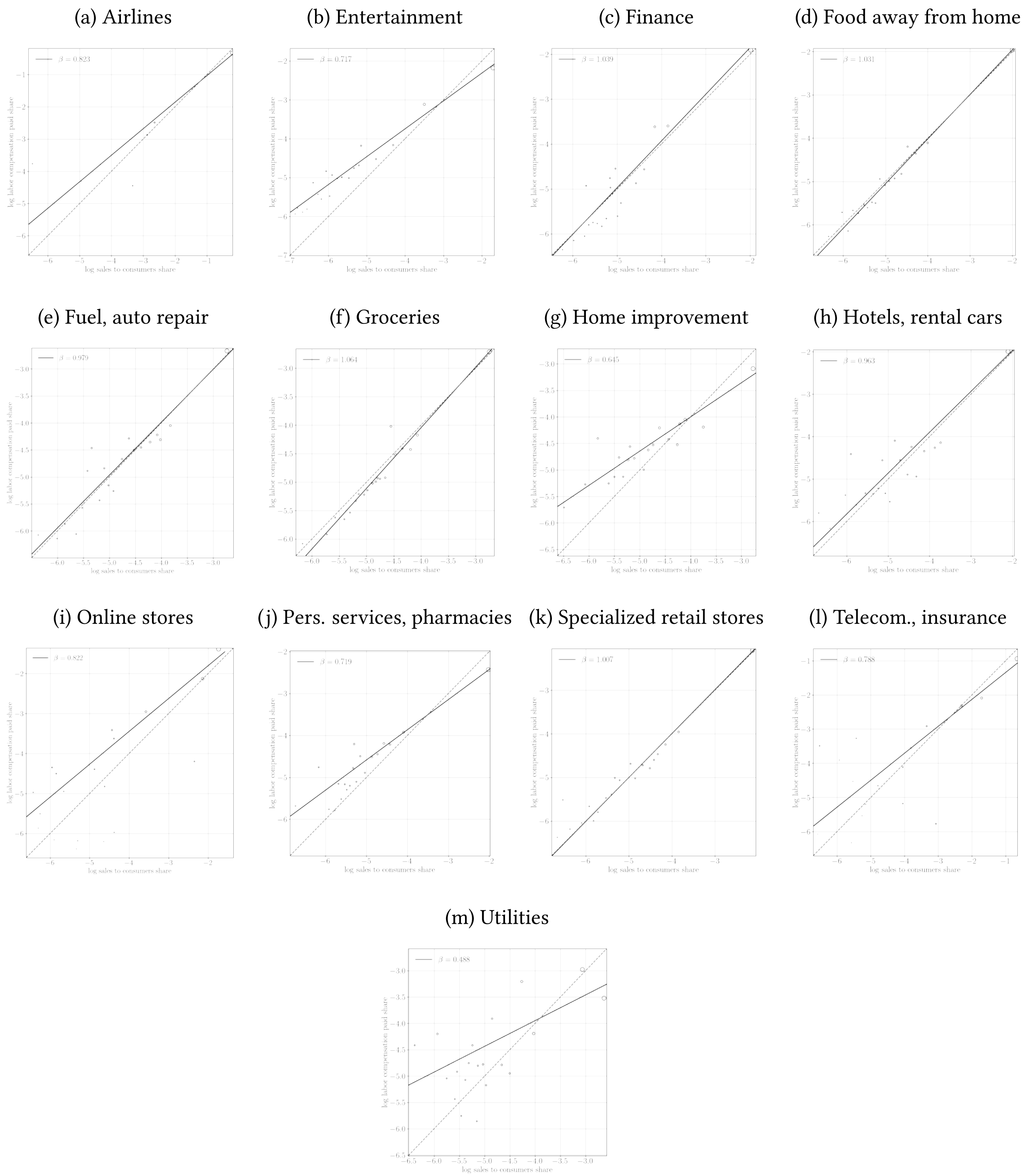
Notes: The figure compares spending shares of consumer regions from the disaggregated spending flows with the Danish household budget survey.

Figure A.II: Card spending over time



Notes: The figure compares aggregated card spending over time in data from Danske Bank and Statistics Denmark (statistikbanken.dk/MPK60).

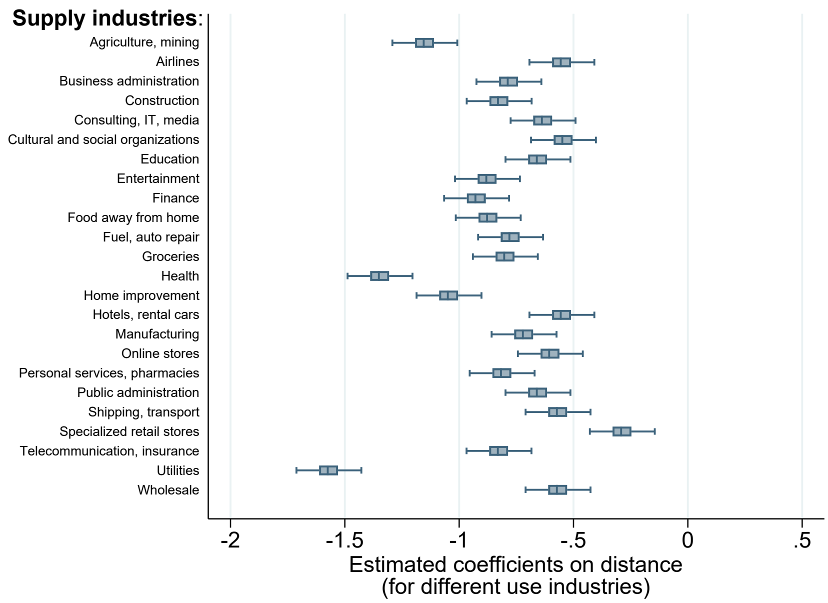
Figure A.III: Labor income shares and spending shares by industry



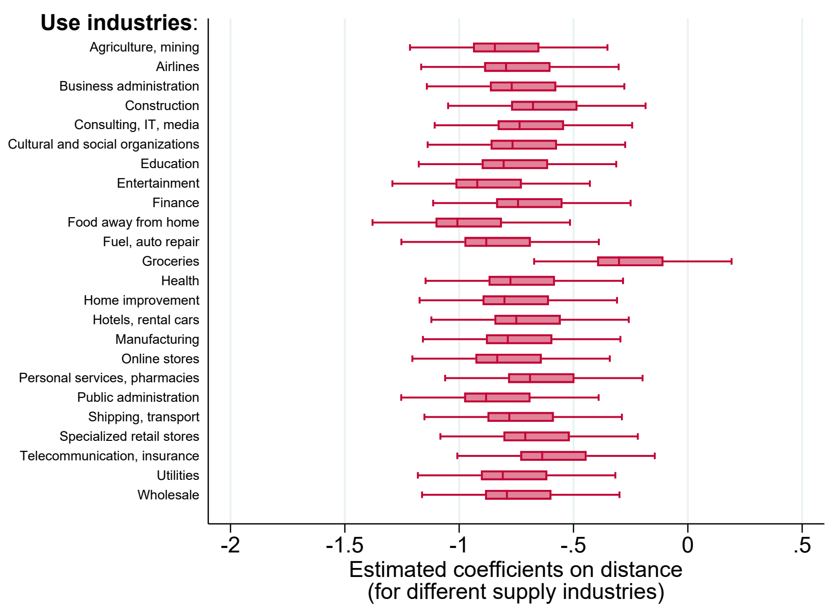
Notes: The sales-weighted binned scatters show the industry-specific relationships between log labor compensation paid (as share of total labor compensation in an industry) and log consumer spending received (as share of total consumer spending in an industry), across regions, for 20 bins of the log share in sales to consumers.

Figure A.IV: Distance coefficients for different industries

(a) By supply industry

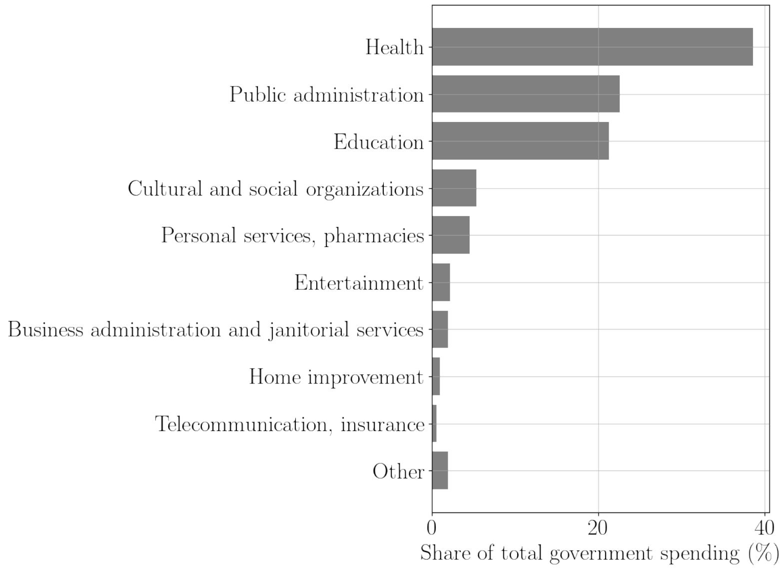


(b) By use industry



Notes: The figure illustrates how the effect of distance on producer-to-producer trade varies across industries. We use a gravity specification to obtain estimates of the elasticity of trade with respect to distance for each combination of supply industry and use industry (576 estimates). Panel a shows the distribution of distance elasticity estimates for each supply industry separately (24 estimates in each case). Panel b shows the distribution of distance elasticity estimates for each use industry separately (24 estimates in each case). The box plots indicate the median elasticity estimate (the line inside the box), the quartiles (the edges of the box), and the upper and lower adjacent values (the whiskers).

Figure A.V: Distribution of government spending across industries



Notes: This figure shows an industry's share in total government spending.

Table A.I: Classification of industries

	Producer industry	Produces output	Sells directly to consumers	Pays labor compensation to consumers ("work industry")
1	Food away from home	Yes	Yes	Yes
2	Entertainment	Yes	Yes	Yes
3	Groceries	Yes	Yes	Yes
4	Personal services, pharmacies	Yes	Yes	Yes
5	Vehicles, fuel, vehicle repair, public transport	Yes	Yes	Yes
6	Hotels, rental cars	Yes	Yes	Yes
7	Airlines	Yes	Yes	Yes
8	Telecommunication, insurance	Yes	Yes	Yes
9	Online stores	Yes	Yes	Yes
10	Utilities	Yes	Yes	Yes
11	Specialized retail stores	Yes	Yes	Yes
12	Home improvement	Yes	Yes	Yes
13	Consulting, information technology, media	Yes	No	Yes
14	Business administration and janitorial services	Yes	No	Yes
15	Manufacturing	Yes	No	Yes
16	Wholesale	Yes	No	Yes
17	Finance, real estate	Yes	Yes	Yes
18	Cultural and social organizations	Yes	Yes	Yes
19	Agriculture, mining	Yes	No	Yes
20	Construction	Yes	No	Yes
21	Shipping, transport	Yes	No	Yes
22	Out of workforce and others	No	No	No
23	Retired	No	No	No
24	Health	Yes	No	Yes
25	Students	No	No	No
26	Education	Yes	No	Yes
27	Public administration	Yes	No	Yes
28	Unemployed	No	No	No
29	Private landlords	Yes	Yes	No
30	Owner-occupied housing	Yes	Yes	No
31	Government-owned housing	Yes	Yes	No

Notes: The table lists the industry classification used throughout the paper. Specialized retail stores include shops selling a specialized set of goods not listed in another industry, e.g., books, computers, shoes, clothing.

Table A.II: Summary statistics on the population and Danske Bank sample

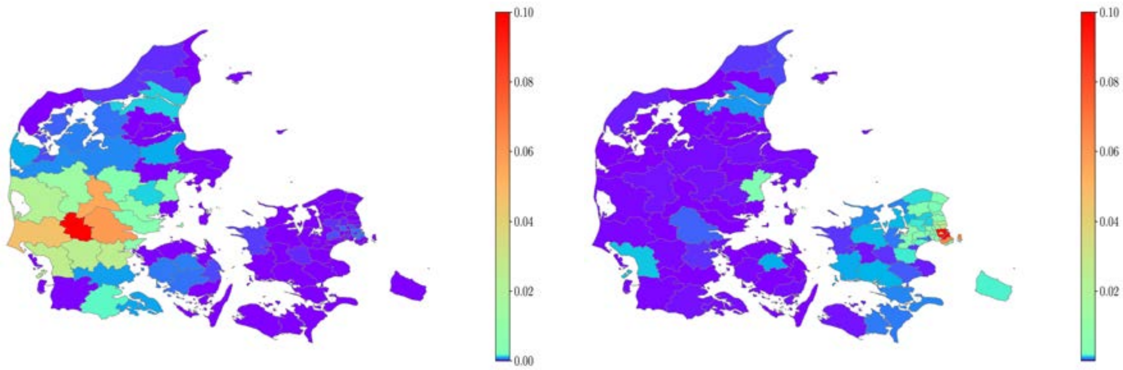
	Full population	Danske Bank sample
Number of adults	4,367,226	858,409
Mean age	48.56	49.97
Mean income (DKK)	298,834	281,039
Age distribution		
18-39	0.35	0.34
40-59	0.35	0.32
60+	0.30	0.34
Income distribution		
Quintile 1	0.20	0.22
Quintile 2	0.20	0.23
Quintile 3	0.20	0.21
Quintile 4	0.20	0.18
Quintile 5	0.20	0.17
Ratio of liquid assets to income distribution		
Quintile 1	0.20	0.20
Quintile 2	0.20	0.21
Quintile 3	0.20	0.19
Quintile 4	0.20	0.20
Quintile 5	0.20	0.20

Notes: The table compares summary statistics for the Danish population from administrative registers with our sample of Danske Bank customers.

Appendix A.B Results on Regional Concentration and Spending in Urban Regions

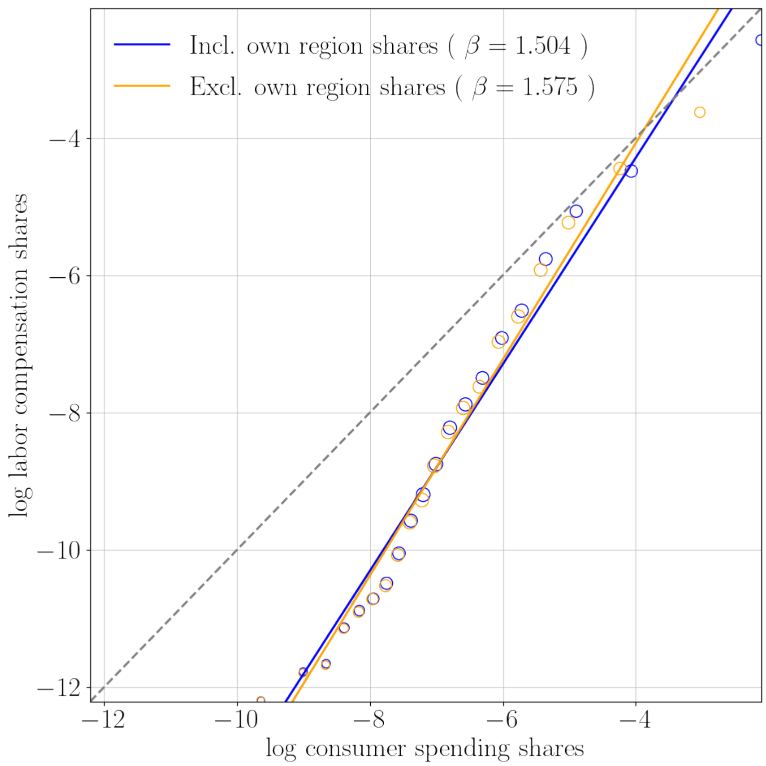
Figure A.VI: Examples of labor compensation received across regions

(a) Manufacturing in Billund (b) Restaurants in Copenhagen



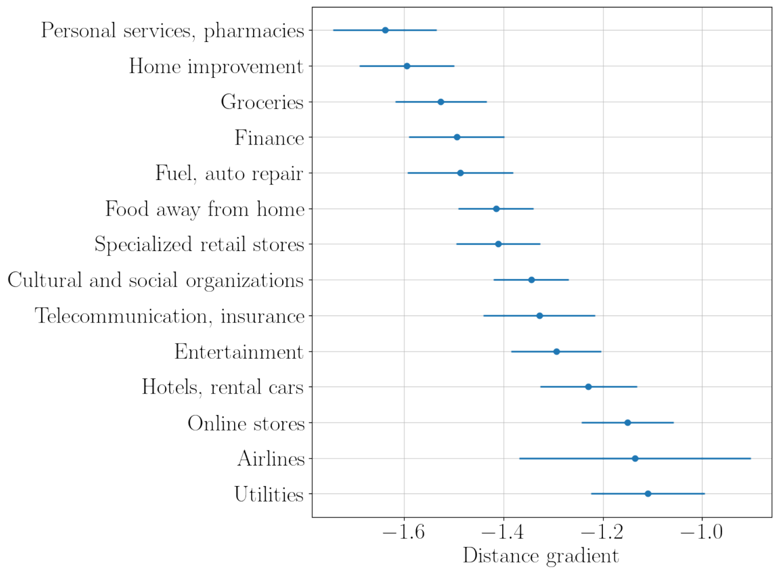
Note: We plot the fraction of labor compensation received by consumers in each region, paid by manufacturing firms in Billund (Panel a) and restaurants in Copenhagen (Panel b). The scale is truncated at 0.10.

Figure A.VII: Labor compensation shares and domestic consumer spending shares



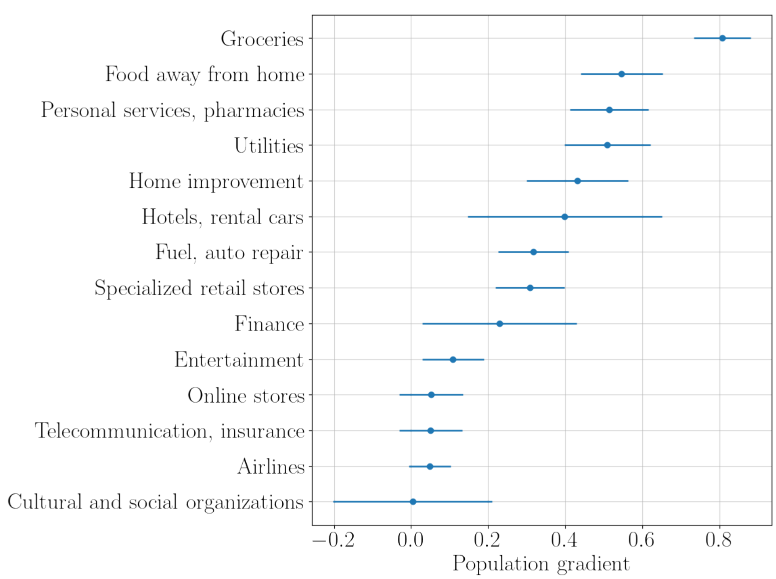
Notes: The figure compares the origin of labor compensation and the destination of consumer spending of consumer cells. It shows that the geographical distributions of labor compensation and consumer spending are highly correlated. For each consumer cell i, we compute the share of labor compensation paid by each producer cell and the share of consumer spending going to each producer cell. The figure plots a scatter plot with 20 bins for these labor compensation and consumer spending shares. We produce versions that include or exclude flows to and from the home region. Weights are proportional to the number of Danske Bank customers in a consumer cell.

Figure A.VIII: Gravity coefficients of labor compensation flows, by industry



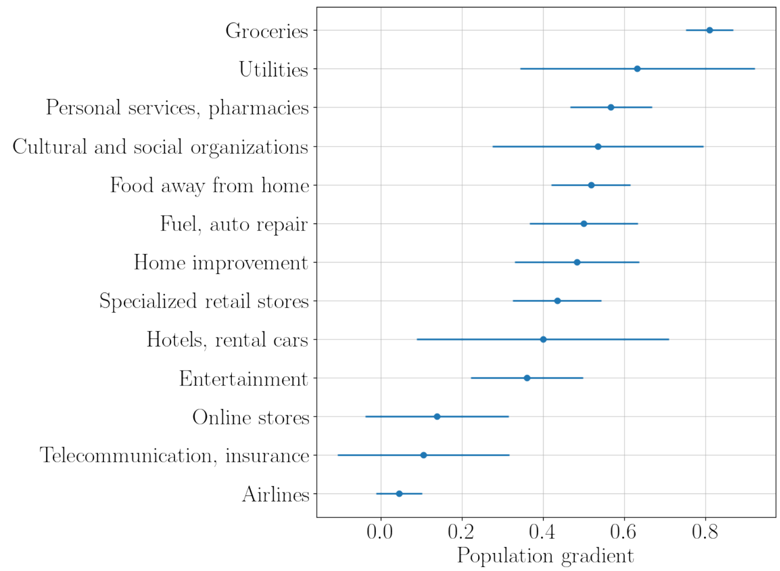
Notes: This figure shows regression coefficients for β using equation (2) for labor compensation flows by paying industry. We exclude observations with zero distance or zero flow. Distance is measured using driving distance between region centers. The error bars represent 95% confidence intervals. Standard errors are two-way clustered by origin and destination cell.

Figure A.IX: Population of home and receiving region: all spending



Notes: This plot shows the estimated coefficient of a regression of the average log population of regions receiving consumer spending within a specific receiving industry on the log population of the spending consumer cell. The error bars represent 95% confidence intervals. Standard errors are two-way clustered by origin and destination cell.

Figure A.X: Population of home and receiving region: only in-person spending



Notes: This plot replicates Figure A.IX using data for only spending carried out in person. Finance is excluded since offline spending is rarely observed for it. Standard errors are two-way clustered by origin and destination cell.

Table A.III: Gravity regressions

	log spending	log labor comp.	log intermediates	log mixed inc., surplus
	(1)	*(2)*	*(3)*	*(4)*
log distance	-1.463^{***}	-1.482^{***}	-0.641^{***}	-0.078^{***}
	(0.028)	(0.013)	(0.010)	(0.012)
Origin FE	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes
Observations	2561036	1654401	5544292	4136285
R^2	0.332	0.279	0.074	0.003
F stat.	1268558.6	638069.4	439859.9	11323.5

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Notes: Distances are measured as driving distances between region centers.Standard errors are two-way clustered by origin and destination cell.

Appendix A.C Results on Direct Foreign Spending Shares

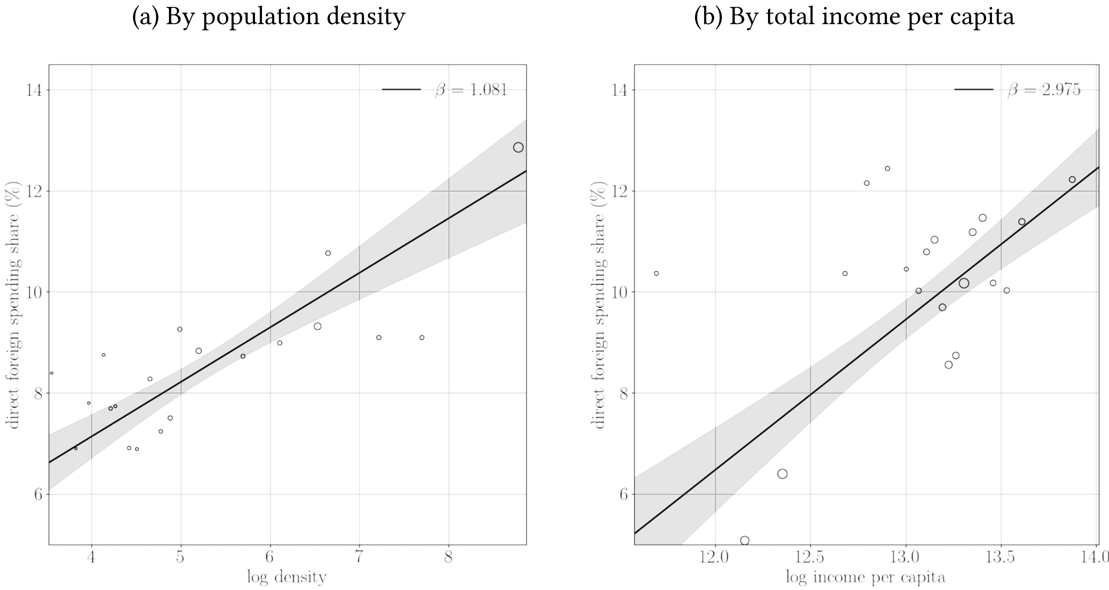
Table A.V: Direct foreign spending shares

	direct foreign spending share (%)							
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
log population	1.622***		1.766***			1.664***	1.616***	1.648***
	(0.264)		(0.244)			(0.229)	(0.225)	(0.218)
log spending per capita		3.683***	4.724***			3.737***	3.887***	5.009***
		(0.595)	(0.576)			(0.641)	(0.618)	(0.960)
distance to border				−1.871***		−1.329***		
				(0.319)		(0.256)		
duration to border					−2.746***		−1.897***	−1.861***
					(0.429)		(0.320)	(0.313)
log pop. × log spending p.c.								2.755**
								(1.139)
const	−8.362***	−34.926***	−67.494***	17.997***	21.324***	−48.573***	−47.713***	−61.803***
	(2.820)	(7.271)	(7.333)	(1.527)	(1.931)	(7.888)	(7.731)	(11.796)
Observations	2741	2741	2741	2741	2741	2741	2741	2741
R^2	0.226	0.060	0.323	0.125	0.142	0.382	0.386	0.412
F stat.	37.7	38.3	64.0	34.3	41.0	47.1	48.5	37.3

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

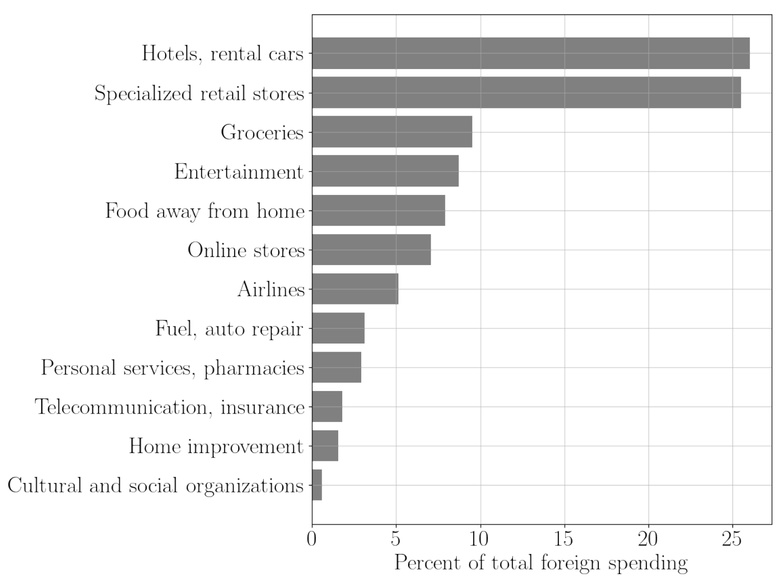
Notes: Foreign spending shares are in percent. For the log population × log income per capita interaction, the two individual variables are demeaned. We weight observations using the number of Danske Bank customers per cell. Standard errors are robust. We measure driving distance and driving duration from region centers to the nearest of eight foreign addresses (Malmø, Helsingborg, Rostock, Puttgarden, and four large border shopping centers along the Jutland-Germany border) using Google Maps API services.

Figure A.XI: Foreign spending by population density and total income



Notes: Panel a shows the direct foreign spending share of consumer cells by their home region's log population density, defined as log of population divided by area. Panel b shows the direct foreign spending share by log income per capita. Panel b excludes consumers who are "not in the workforce" as their income is likely mismeasured due to the absence of within-household transfer flows in the current iteration of the DEA. Both plots are binned scatter plots with 20 bins mirroring the number of regions in our analysis. Weights are the number of Danske Bank customers in a municipality. The shaded area represents 95% robust confidence intervals.

Figure A.XII: Foreign spending shares by receiving industry



Notes: This bar graph shows the distribution of direct foreign spending by consumers across industries receiving spending.

Appendix A.D Internal Trade Balance by Industry

Table A.VII: External trade surplus across regions by size

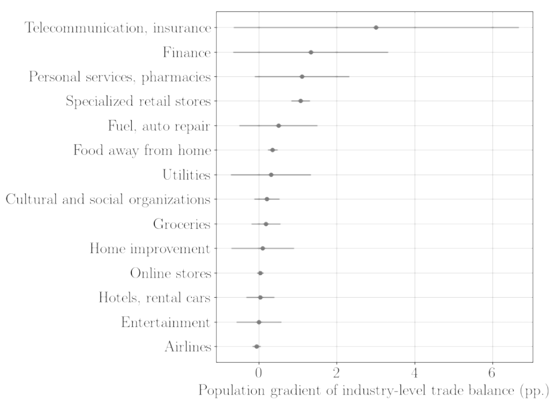
Regions	Adult population	External trade surplus	External trade surplus per adult
15 most populous regions	1’962’365	27.39 bn DKK	13’956 DKK
70 least populous regions	1’970’472	124.47 bn DKK	63’166 DKK

Table A.VIII: Internal trade surplus across regions by size

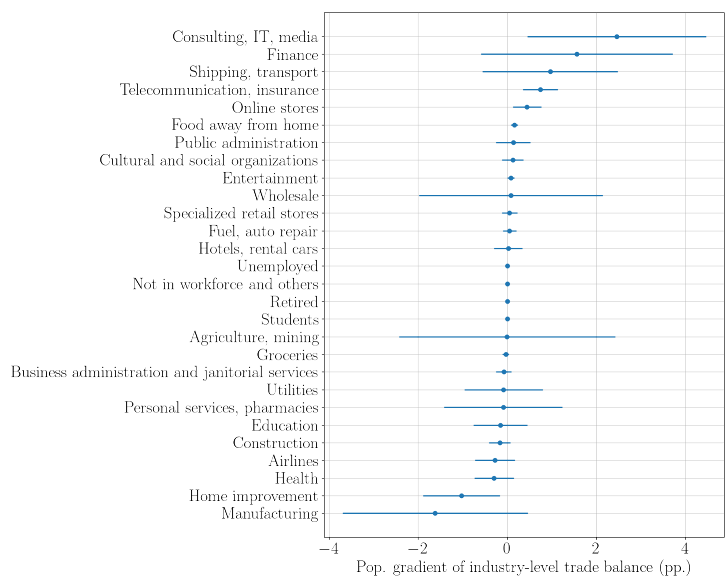
Regions	Adult population	Internal trade surplus	Internal trade surplus per adult
15 most populous regions	1’962’365	534.87 bn DKK	272’564 DKK
70 least populous regions	1’970’472	297.00 bn DKK	150’724 DKK

Figure A.XIII: Internal trade balance and population size by industry

(a) Consumers spending



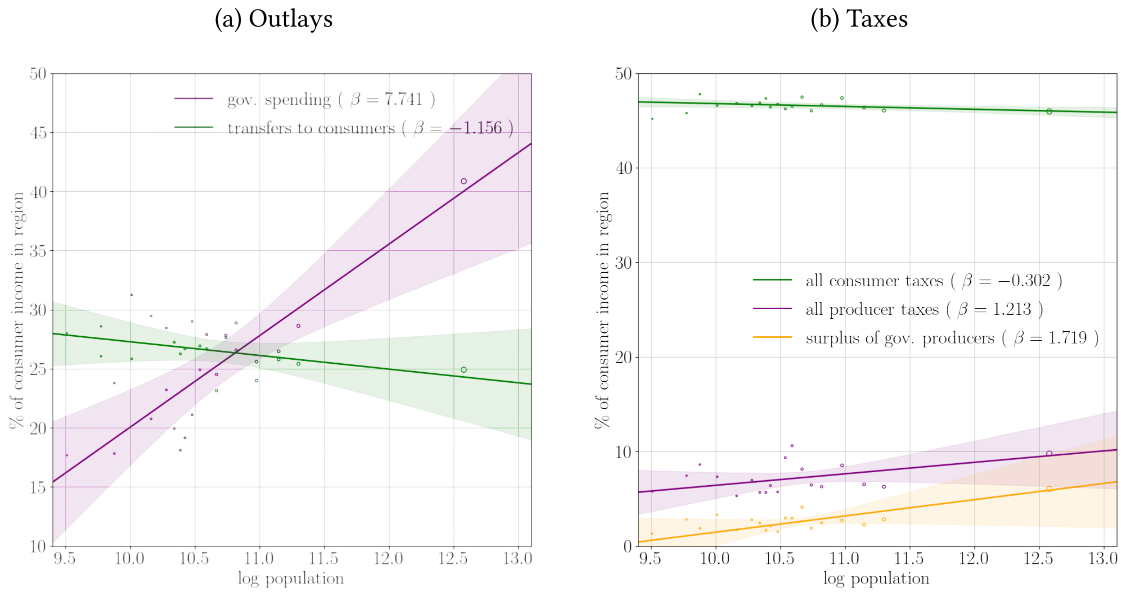
(b) Intermediate input trade



Notes: This plot shows estimated coefficients of a regression of industry-level internal trade balance (sales minus purchases by region residents elsewhere in Denmark) on log population, across regions. Weights are region GDP. Error bars represent 95% robust confidence intervals.

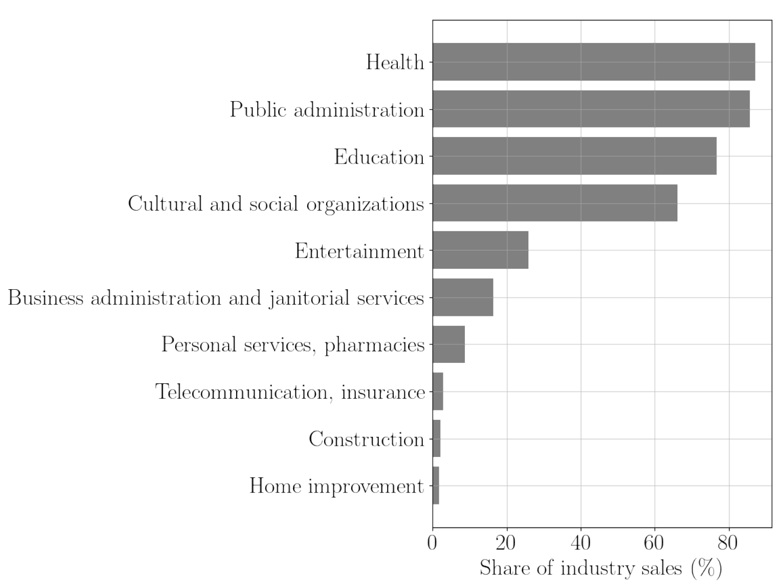
Appendix A.E Results on the Role of the Government in Denmark

Figure A.XIV: Government outlays and taxes across regions (by region GDP)



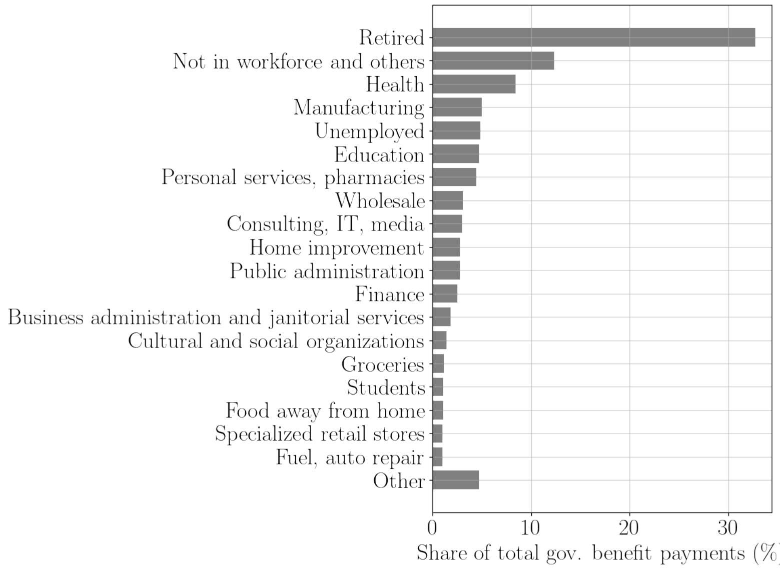
Notes: The panels show all flows between individual regions and the government, normalized by regional income, for 20 evenly sized bins of regional population size. Weights are regional income. Shaded areas are 95% robust confidence intervals.

Figure A.XV: Share of producer sales accounted for by government spending



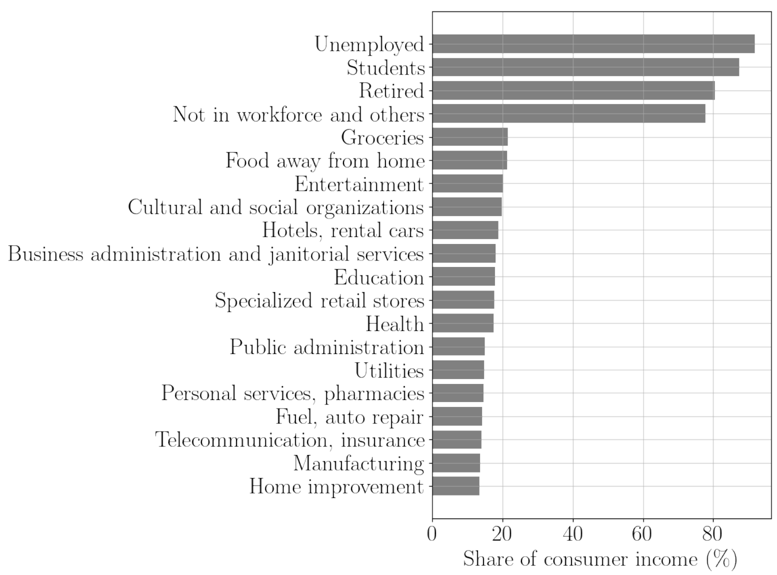
Notes: This figure shows the share of an industry's total sales accounted for by government spending, for the 10 industries with the largest shares.

Figure A.XVI: Share of total social benefits received by consumer industry



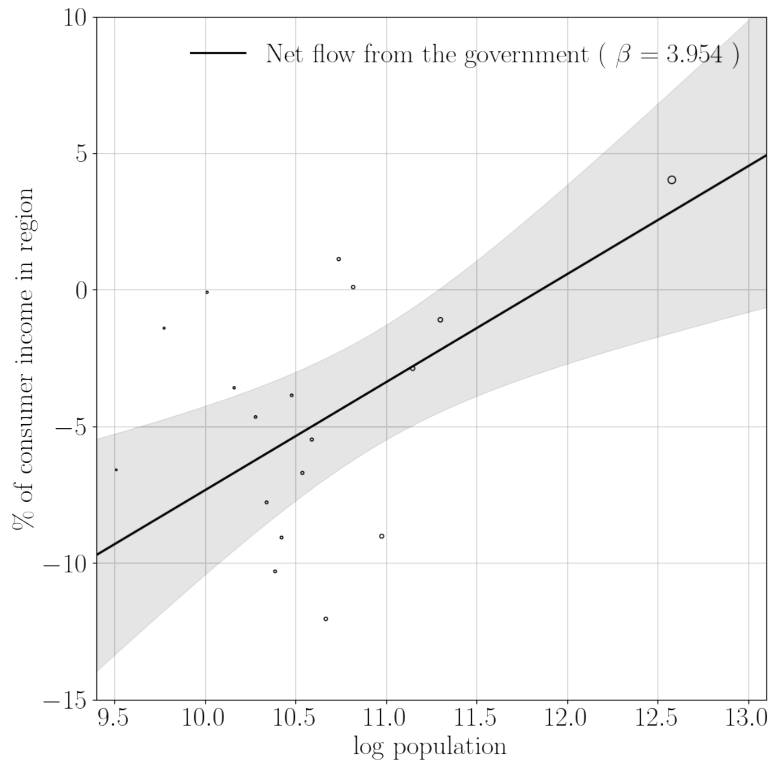
Notes: This figure shows the share of total government social benefits received by different consumer industries, for 19 industries, with the remaining industries collected in "other."

Figure A.XVII: Government benefits received as share of consumer income



Notes: This figure shows the share of total consumer income that is accounted for by government social benefits received across consumer industries. Top 20 industries shown.

Figure A.XVIII: Net inflow received from the government across regions



Notes: This figure shows the net of all government outlays less taxes, relative to regional income, for 20 evenly sized bins of regional population size. Weights are regional income. Shaded areas are 95% robust confidence intervals.

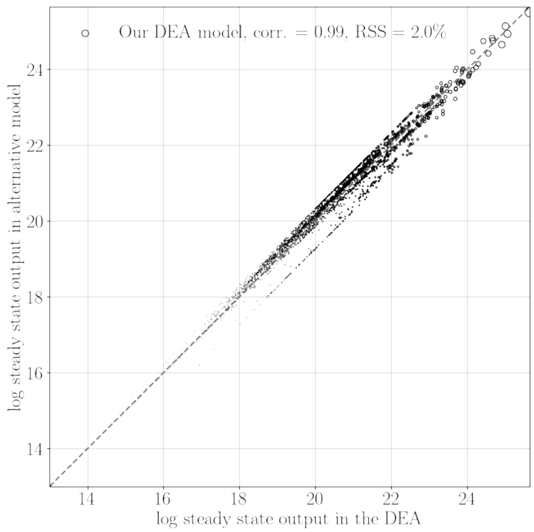
Appendix A.F Details on Calibration

Table A.IX: Calibration overview

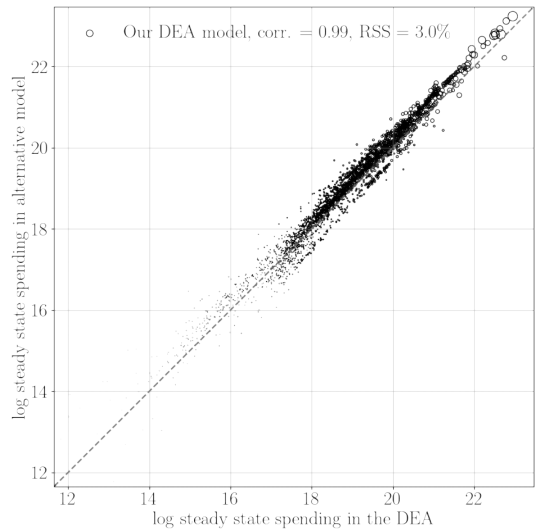
Parameter(s)	Symbol	Calibration target	Flow numbers from Table I
Spending shares	$\alpha_{i\mathcal{R}}, \alpha_{is}, \alpha_{isj}$	Disaggregated consumer spending flows	1, 2
Value-added tax rate	τ_i^{vat}	Consumer product taxes paid	3
Income tax rate	τ_i	Consumer non-product taxes and social contributions	4, 5
Labor compensation shares	λ_{ij}, γ_j^N	Disaggregated labor comp. flows, incl. to foreign workers	10, 28
Profit income shares	κ_{ij}, γ_j^K	Mixed income, surplus to consumers	11, 12, 13
Gov. transfer share of gov. revenue	t_i	Consumer social benefits received, pension adjustment	14, 15
Foreign demand for domestic labor shifter	$\tilde{N}_{i\mathcal{R}}$	Labor compensation paid by foreign producers	20
Intermediate input shares, imports	$\omega_{js}, \omega_{jsj'}, \gamma^X$	Trade flows in domestic intermediates, producer imports	21, 27
Corporate tax rate	τ_j^{corp}	Dividends and surplus from gov. enterprises, taxes	22, 23, 24, 25
Gov. spending share of gov. revenue	g_j	Domestic government spending	29
Relative distribution of exports	$\tilde{x}_j/\tilde{x}_{j'}$	Producer exports	31
Gov. import share of gov. revenue	$\tilde{g}$	Government imports	32
Aggregate export flows	$\tilde{x}_j$	Aggregate GDP	
Share of gov. spending consumed by cell i	ν_i	Arbitrary	
Utility weight on gov. spending	ψ_i	Samuelson (1954) condition	
Within-industry elasticity of sub. of consumers	σ	Cobb-Douglas (1) as baseline, 2 later	
Elasticity of export demand	$\tilde{\sigma}$	Cobb-Douglas (1) as baseline, 2 later	
Within-industry elasticity of sub. b/w labor	ζ	Cobb-Douglas (1) as baseline, 2 later	
Elasticity of foreign demand for domestic labor	$\tilde{\zeta}$	Cobb-Douglas (1) as baseline, 2 later	
Within-industry elasticity of sub. b/w intermediates	η	Cobb-Douglas (1) as baseline, 2 later	

Figure A.XIX: Match between model economy and disaggregated accounts

(a) Sales by producer cell



(b) Domestic consumer spending



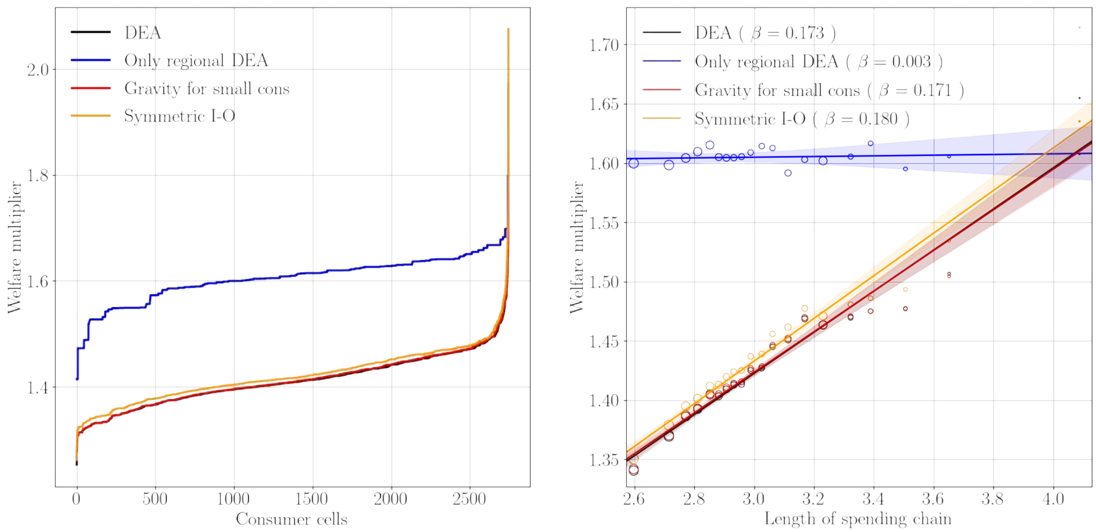
Notes: Panel a shows a scatter plot of log producer cell output in the model relative to the disaggregated accounts. Node size is proportional to producer cell output in the disaggregated accounts. Panel b shows a scatter plot of log consumer spending in the model relative to the disaggregated accounts. Node size is proportional to domestic spending in the disaggregated accounts. "corr" stands for correlation. "RSS" stands for the residual sum of squares. RSS captures the variance in the data not explained by the model, var$(y^{data} - y^{model})$, for any variable y, in percent of variance in the data var(y^{data}). RSS larger than 100% would imply that the variation in the model does not explain the data well.

Appendix A.G Results for Application I

Figure A.XX: Robustness: Welfare multipliers in the DEA

(a) Distribution of multipliers

(b) Multipliers by length of spending chain

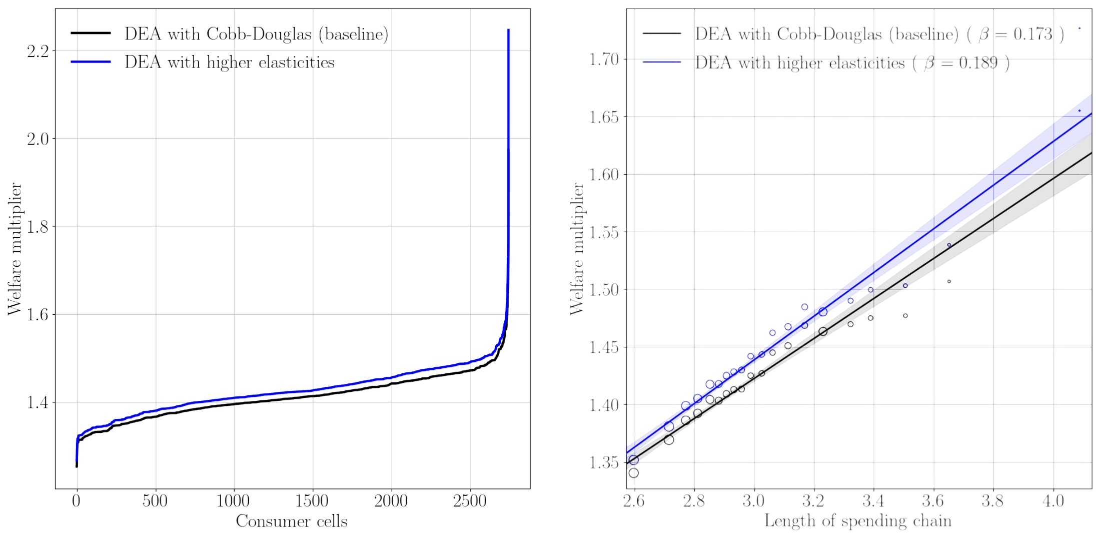


Notes: Welfare multipliers (or marginal value of public funds) are computed as the marginal aggregate welfare benefit in response to a transfer. Panel a shows the distribution of welfare multipliers across consumers cells, weighted by a consumer cell's population. Panel b shows welfare multipliers by the length of the spending chain (20 bins), weighted by cell population. "DEA" is the full model calibrated to match the disaggregated accounts; "Only regional DEA" is a model in which all consumer and producer cells within a region are assumed to be symmetric; "Gravity for small cons." is a model in which the 90% smallest bilateral consumer spending flows are replaced by a gravity approximation; "Symmetric I-O" is a model in which input-output flows are symmetric across industries. Shaded areas are 95% robust confidence intervals.

Figure A.XXI: Robustness to higher elasticities: Welfare multipliers in the DEA

(a) Distribution of multipliers

(b) Multipliers by length of spending chain



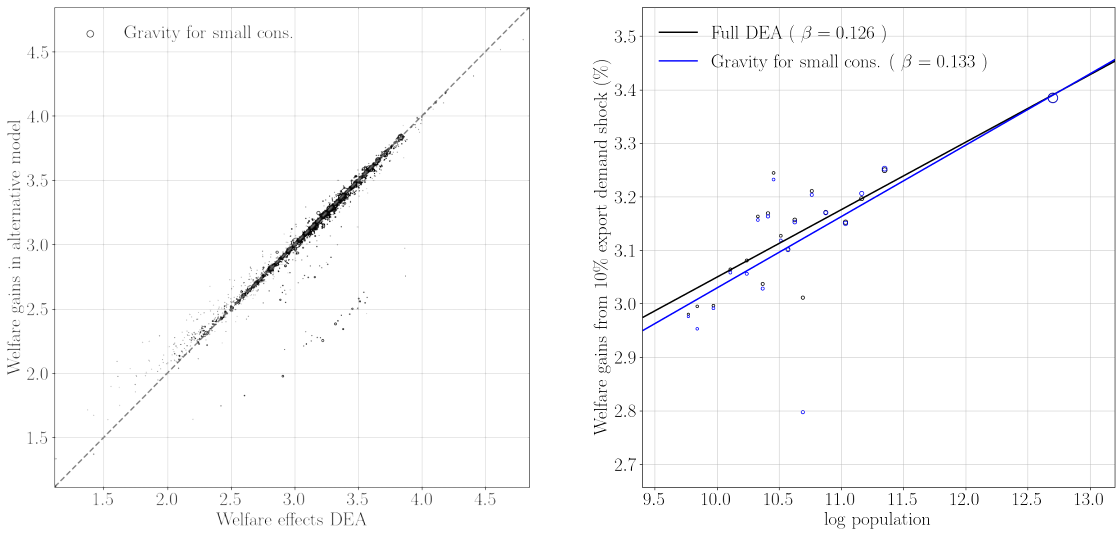
Notes: Welfare multipliers (or marginal value of public funds) are computed as the marginal aggregate welfare benefit in response to a transfer. Panel a shows the distribution of welfare multipliers across consumers cells, weighted by a consumer cell's population. Panel b shows welfare multipliers by the length of the spending chain (20 bins), weighted by cell population. "DEA with Cobb-Douglas" is the full model calibrated to match the disaggregated accounts; "DEA with higher elasticities" is a model in which we assume that $\sigma = \tilde{\sigma} = \zeta = \tilde{\zeta} = \eta = 2$. Shaded areas are 95% robust confidence intervals.

Appendix A.H Results for Application II

Figure A.XXII: Testing for overfitting of disaggregated consumer spending: Distributional gains from uniform export shock

(a) Comparing welfare gains with the DEA

(b) Welfare gains by log population

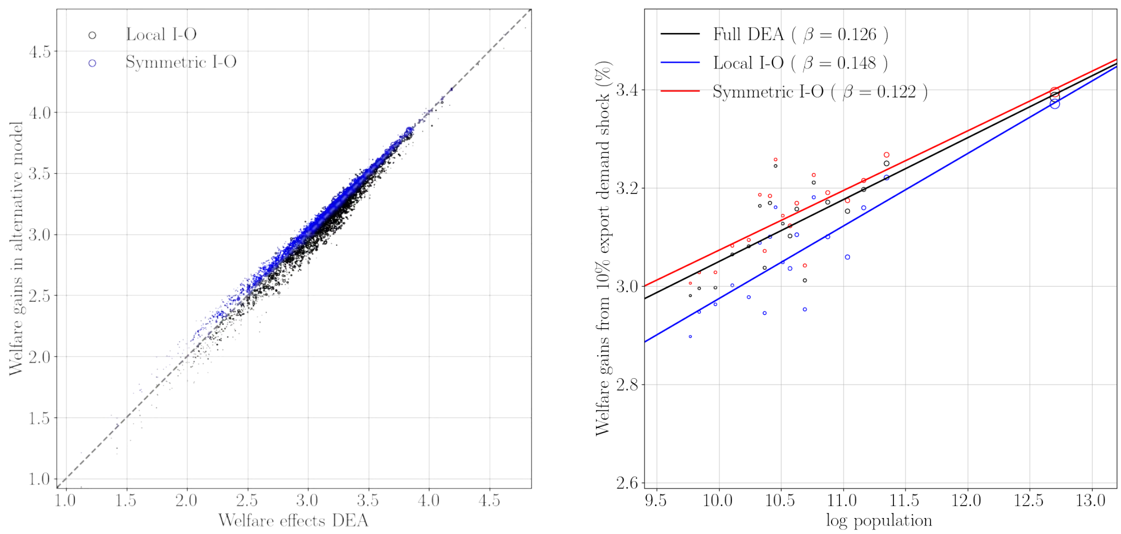


Notes: Panel a compares the distribution of the welfare gains from a 10% increase in overall export demand across two models: the full DEA model; and a model that is equal in all regards, and calibrated exactly as outlined in Section VI, except that the smallest 90% of the bilateral consumer spending flows by imputed values from the standard gravity regression (2). Panel b shows a binned scatter plot of welfare gains across log region population across the models. Weights are number of Danske Bank customers per cell.

Figure A.XXIII: Testing for measurement error in the disaggregated intermediates trade flows: Distributional gains from uniform export shock

(a) Comparing welfare gains with the DEA

(b) Welfare gains by log population

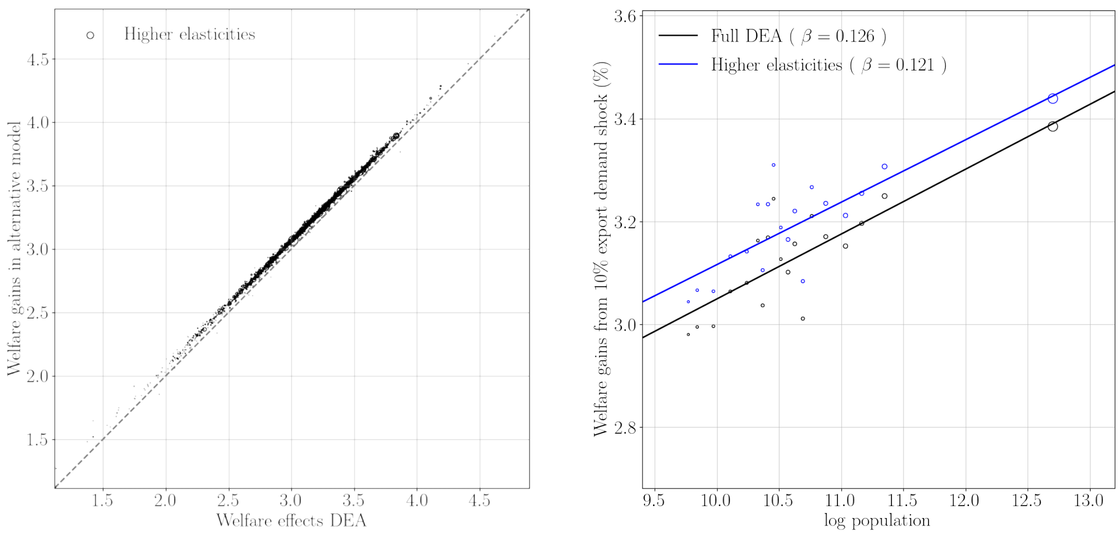


Notes: Panel a compares the distribution of the welfare gains from a 10% increase in overall export demand across two models: the full DEA model and two modified models. Both modified models are equal in all regards, and calibrated exactly as outlined in Section VI, except that: the first modified model assumes that all intermediates trade flows are local and do not cross region borders; the second modified model assumes that all intermediates trade flows are symmetric across purchases, that is, the input-output matrix is replaced by the unique rank-1 matrix that has the same column sums and same row sums as the correct input-output matrix. Panel b shows a binned scatter plot of welfare gains across log region population across the models. Weights are number of Danske Bank customers per cell.

Figure A.XXIV: Comparison of distributional welfare gains under Cobb-Douglas with ones for higher elasticities

(a) Comparing welfare gains with the DEA

(b) Welfare gains by log population



Notes: Panel a compares the distribution of the welfare gains from a 10% increase in overall export demand across two models: the DEA model with unitary elasticity of substitution and one with higher elasticities of substitution, $\sigma = \zeta = \gamma = \eta = 2$. Panel b shows a binned scatter plot of welfare gains across log region population across the models. Weights are number of Danske Bank customers per cell.

Appendix B Accounting Identities and T-Tables by Cell Type

The accounting identity for consumer cell i is

$$\begin{aligned}
&\text{Domestic consumer spending}_i + \text{Foreign consumer spending}_i \\
&+ \text{Consumer taxes}_i + \text{Interest, transfers, and saving paid}_i \\
&= \text{Labor comp}_i + \text{Producer dividends, mixed inc, and surplus}_i \\
&+ \text{Government benefits}_i + \text{Interest and transfers rec}_i.
\end{aligned}$$

The accounting identity for producer cell j is

$$\begin{aligned}&\text{Domestic intermediate spending}_j + \text{Labor comp}_j\\&+\ \text{Producer dividends, mixed inc, and surplus}_j\\&+\text{Dividends and surplus of government producers}\\&+\text{Producer net taxes}+\text{Producer net interest, transfers, and saving paid}_j+\text{Imports}_j\\&=\text{Domestic intermediate sales}_j+\text{Domestic consumer spending}_j\\&+\text{Domestic government spending}_j+\text{Domestic capital acc. spending}_j+\text{Exports}_j.\end{aligned}$$

We include one cell each for the Danish government, the rest of the world, and capital accumulation, so accounting identities have no subscripts for the government,

$$\begin{aligned}&\text{Domestic government spending}+\text{Government imports}\\&+\text{Government benefits}\\&+\text{Government net interest, transfers, and saving paid}\\&=\text{Consumer taxes}+\text{Producer net taxes}\\&+\text{Dividends and surplus of government producers},\end{aligned}$$

for the rest of the world,

$$\begin{aligned}&\text{Foreign consumer spending}+\text{Producer imports}\\&+\text{Government imports}+\text{Capital acc imports}+\text{Trade balance}\\&=\text{Producer exports},\end{aligned}$$

and for the capital accumulation cell,

$$\begin{aligned}&\text{Consumer interest, transfers, and saving rec}+\text{Domestic capital acc. spending}\\&+\text{Capital acc imports}+\text{Trade balance}\\&=\text{Consumer interest, transfers, and saving paid}\\&+\text{Producer net interest, transfers, and saving paid}\\&+\text{Government net interest, transfers, and saving paid.}\end{aligned}$$

Table A.X: Aggregate consumer account

Outflows			Inflows		
Outflow	Outflow to	Value (bn DKK)	Inflow	Inflow from	Value (bn DKK)
Domestic consumer spending	Producers	771.9	Labor compensation paid by domestic producers	Producers	1132.9
Foreign consumer spending	Rest of the world	81.9	Mixed income from non-corporate producers	Producers	80.7
Consumer product taxes paid	Government	173.2	Surplus of corporate producers to consumers (dividends)	Producers	38.5
Consumer non-product taxes paid	Government	566.4	Surplus of owner-occupied housing to consumers	Producers	83.3
Consumer social contributions paid	Government	181.1	Consumer social benefits received	Government	422.2
Consumer interest paid	Capital accumulation	29.7	Consumer adjustment for pension entitlements received	Government	92.5
Consumer natural resource rents paid	Capital accumulation	3.4	Consumer interest received	Capital accumulation	5.3
Consumer other transfers paid	Capital accumulation	44.8	Consumer pension investment income	Capital accumulation	75.5
Consumer gross saving	Capital accumulation	130.1	Consumer natural resource rents received	Capital accumulation	3.4
			Consumer other transfers received	Capital accumulation	39.2
			Labor compensation paid by foreign producers	Rest of the world	8.9
Total value outflows		1982.4	**Total value inflows**		1982.4

Table A.XI: Aggregate producer account

Outflows			Inflows		
Outflow	Outflow to	Value (bn DKK)	Inflow	Inflow from	Value (bn DKK)
Labor compensation paid to domestic employees	Consumers	1132.9	Domestic consumer spending	Consumers	771.9
Mixed income from non-corporate producers	Consumers	80.7	Domestic intermediates	Producers	1423.4
Surplus of corporate producers to consumers (dividends)	Consumers	38.5	Domestic government spending	Government	572.3
Surplus of owner-occupied housing to consumers	Consumers	83.3	Domestic capital accumulation spending	Capital accumulation	359.5
Domestic intermediates	Producers	1423.4	Producer exports	Rest of the world	1077.9
Dividends and surplus of government-owned/operated producers to government	Government	67.9			
Producer product and import taxes paid	Government	71.9			
Producer net production-related taxes	Government	20.9			
Producer taxes paid on income	Government	61.9			
Producer net interest, transfers, and saving	Capital accumulation	409.9			
Producer imports	Rest of the world	792.3			
Labor compensation paid to foreign workers	Rest of the world	21.4			
Total value outflows		4205	**Total value inflows**		4205

Table A.XII: Aggregate government account

Outflows			Inflows		
Outflow	Outflow to	Value (bn DKK)	Inflow	Inflow from	Value (bn DKK)
Consumer social benefits received	Consumers	422.2	Consumer product taxes paid	Consumers	173.2
Consumer adjustment for pension entitlements received	Consumers	92.45	Consumer non-product taxes paid	Consumers	566.4
Domestic government spending	Producers	572.3	Consumer social contributions paid	Consumers	181.1
Government imports	Rest of the world	4.3	Dividends and surplus of government-owned/operated producers to government	Producers	67.9
Government net interest, transfers, and saving	Capital accumulation	52	Producer product and import taxes paid	Producers	71.9
			Producer net production-related taxes	Government	20.9
			Producer taxes paid on income	Government	61.9
Total value outflows		1143.2	**Total value inflows**		1143.2

Table A.XIII: Aggregate rest of the world account

Outflows			Inflows		
Outflow	Outflow to	Value (bn DKK)	Inflow	Inflow from	Value (bn DKK)
Producer exports	Producers	1077.9	Aggregate trade balance	Capital accumulation	88
Labor compensation paid by foreign producers	Consumers	8.9	Foreign consumer spending	Consumers	81.9
			Producer imports	Producers	792.3
			Labor compensation paid to foreign workers	Rest of the world	21.4
			Government imports	Government	4.3
			Capital accumulation cell imports	Capital accumulation	98.9
Total value outflows		1086.9	**Total value inflows**		1086.9

Table A.XIV: Aggregate capital accumulation account

Outflows			Inflows		
Outflow	Outflow to	Value (bn DKK)	Inflow	Inflow from	Value (bn DKK)
Consumer interest received	Consumers	5.3	Consumer interest paid	Consumers	29.7
Consumer pension investment income	Consumers	75.5	Consumer natural resource rents paid	Consumers	3.4
Consumer natural resource rents received	Consumers	3.4	Consumer other transfers paid	Consumers	44.8
Consumer other transfers received	Consumers	39.2	Consumer gross saving	Consumers	130.1
Domestic capital accumulation spending	Producers	359.5	Producer net interest, transfers, and saving	Producers	409.9
Capital accumulation cell imports	Rest of the world	98.9	Government net interest, transfers, and saving	Government	52
Aggregate trade balance	Rest of the world	88			
Total value outflows		670	**Total value inflows**		670

Appendix C   Overview of Data Sources

We rely on several types of data to construct the disaggregated economic accounts. First, we use data from Danske Bank containing information about individual consumers and their transactions and producer-to-producer transaction data from CrediWire. Second, we use administrative data from government registers, such as the population, income, and employment registers. Third, we use publicly available aggregate statistics, such as housing, healthcare, and financial securities statistics.

In the following appendices, we provide details about the data sources and the disaggregated measurement. Table A.XV lists all the data sources and the relevant Appendix containing details of the measurement.

We strive for consistency across all the disaggregated measurement by relying, whenever possible, on the same sample of individuals, the entire adult population in 2018, and a uniform assignment of individuals and firm establishments to cells based on government registers. The only instance where we need to deviate from these general rules is when we construct the disaggregated consumer spending flows. Here, we work with the sample of Danske Bank customers, roughly 20% of the national adult population, and we assign individuals and firm establishments to cells using the bank's internal data, as confidentiality concerns prevent us from merging the bank data and government registers.

The aggregates of our bottom-up calculations are typically slightly lower than the national accounts aggregate, mostly because our sample contains only adults, so we ultimately scale each cell-level observation by a common scaling factor to match the national aggregate exactly.

Table A.XV: Overview of data sources

Disaggregated data type	Microdata from private sources	Microdata from the government	Aggregate statistics	Details
Region-by-industry cells	Danske Bank customer records and incoming transactions, CrediWire customer records	Population register (BEF), labor market register (AKM), income register (IND), employment registers (BFL, IDAN)		Appendix D
Consumer spending	Danske Bank customer records and payment transactions	Income register (IND), credit register (URTE), auto register (DMR)	National housing statistics (BOL101)	Appendix E
Consumer and producer product taxes	Danske Bank payment transactions	Income register (IND), employment register (BFL)	Input-output table (NIO3)	Appendix F
Consumer and producer non-product taxes		Income register (IND), pension contribution register (INPI), population register (BEF)		Appendix G
Consumer interest, transfers, and saving (paid)		Population register (BEF), income register (IND)		Appendix H
Labor compensation		Income register (IND), pension contribution register (INPI), employment register (BFL)		Appendix I
Consumer dividend, mixed income, and surplus		Income register (IND), employment register (IDAN)	General firm statistics (GF5), registered securities statistics (DNVPDKS)	Appendix J
Government benefits to consumers		Income register (IND), pension contribution register (INPI), population register (BEF)		Appendix K
Consumer interest, transfers, and saving (received)		Population register (BEF), income register (IND)		Appendix L
Intermediates trade	CrediWire customer records and transaction-level data on payments	Income register (IND)	Input-output tables (NIO1, NIO2, NIO3)	Appendix M
Exports and imports	Danske Bank payment transactions	Foreign trade registry (UHDI), firm sales and purchases registry (FIKS), income register (IND)	Input-output tables (NIO1, NIO2, NIO3), overnight stays by foreigners from VisitDenmark	Appendix N
Government dividend and surplus income		CVR register (hand-collected)		Appendix O
Consumption of government and NPISH output	Danske Bank customer records and incoming transactions	Population register (BEF), education register (UDD), income register (IND)	Public expenditure statistics (SYGU1), health statistics (INDAMP01), education statistics (UDDAKT20), child care statistics (BOERN4), culture and leisure statistics (BIB1)	Appendix Q

Appendix D Defining Region-by-Industry Cells

The unit of our measurement are region-by-industry cells, the interaction of geographical regions and economic industries. Specifically, we define 99 regions (98 Danish municipalities and one foreign region) and 31 industries (Table A.I). We choose this definition of region and industries because we can observe it consistently across all underlying datasets and because it reveals a large degree of heterogeneity in disaggregated flows.

There are 24 industries that pay labor compensation to consumers. They include retail industries selling directly to consumers (e.g., food away from home, entertainment, grocery stores, drug stores), non-retail industries transacting mostly with firms (e.g., wholesale, agriculture, manufacturing, business services), and government-operated industries (e.g., public administration, health, education). We map six-digit NACE industry codes to the 24 industries that employ workers. Additionally, there are 4 separate industries for the non-working parts of the population (e.g., retired, students, unemployed, out of workforce) and 3 industries providing housing without employees.

In the government registers, we assign all adults to a region based on their home address at the start of 2018, as observed in the administrative population register (BEF), and to an industry based on the NACE code of the firm establishment responsible for the largest part of their 2018 labor income, as observed in the labor market register (AKM). Individuals without labor income are assigned to an industry based on their age, observed in the administrative population register (BEF), and other income sources, observed in the income register (IND). Specifically, individuals without labor income are assigned to the industry "retired" if they are older than 65 years; to the industry "students" if they receive a government stipend (for which higher education students are almost universally eligible); to the industry "unemployed" if they receive unemployment or cash benefits; and otherwise to the industry "out of workforce." We assign firm establishments to producer region-by-industry cells using information from the employment registers (BFL and IDAN). To ensure anonymity, we censor information for the (very few) consumer cells containing fewer than 3 individuals or establishments in all datasets. In the Danske Bank, CrediWire, and firm export and import data, we follow similar procedures, as outlined below.

Appendix E Measuring Disaggregated Consumer Spending

Appendix E.A Data and Sample

To construct the disaggregated spending flows, we rely on data from Danske Bank for 2018 and 2019. We observe transaction-level information on consumers and merchants only for this period. Our sample consists of adult customers who conducted at least one transaction per month and registered their main bank account at Danske Bank throughout 2018 and 2019.[A1] For each customer, we observe all incoming and outgoing transactions. Card payments accounted for 47% of the total value of payment transactions. The most common card was Dankort (debit cards issued by Nets A/S), followed by MasterCard (debit and credit cards) and Visa (debit and credit cards). Cash withdrawals accounted for 7% of transaction value, whereas bill payments (direct debits and bank transfers to merchants) accounted for 45%. Mobile applications, such as Apple Pay or the Denmark-specific MobilePay, made up 1%.

Appendix E.B Identifying Consumer Region and Industry

We identify consumers' industry by extracting the name of the employer from incoming labor compensation payments and by identifying incoming government transfers (retired, students, government stipend, unemployed). We use the banks' customer records to identify their region of residence. The address register in the bank is linked to the government's address registers and updated on a monthly basis. To ensure that moves across regions do not distort the spending patterns, we update an individual's region every month when constructing the disaggregated spending data. However, consistent with the assignment in the government registers, we define the industry of main employment on an annual basis as the industry paying the largest share of annual consumer income.

Appendix E.C Identifying the Merchant Region

We extract the address of the merchant establishment (i.e., the store) from the string that accompanies payment transactions in the bank's internal computer system. The information for card and mobile payments differs slightly by payment type.

- Dankort statements include a unique ID number for each merchant establishment for transactions in Denmark and the country name for transactions abroad. We match the Danish merchant IDs to the exact merchant address using a table issued by Nets A/S.
- MasterCard includes a detailed merchant address directly in the transaction string in the following format: merchant ID, shop name, street name, house number, postal code, country.
- Visa reports the merchant ID, shop name, and town for each transaction. The merchant IDs used by Visa and MasterCard generally coincide. Based on the MasterCard data, we can therefore construct a table matching merchant ID and detailed address. In very few cases, a

[A1] All adults register one "main" account with the Danish government, through which they conduct all financial interactions with the government.

merchant ID gets used twice for a Danish merchant and a foreign merchant. In these cases, we assume that the transaction was with the Danish merchant.

- Some transactions in MobilePay and Apple Pay contain merchant addresses, but some do not.

For all card and mobile payments, we extract the merchant address and convert it to a consistent format using an API service provided by the government agency Styrelsen for Dataforsyning og Effektivisering (dawa.aws.dk/dok/api/adgangsadresse). This conversion identifies precise geocodes for each merchant while accounting for misspelled addresses and addresses that appear twice due to minor differences in formatting or spelling. The API compares the merchant address from a transaction with its database of official addresses. It iterates in a Levenshtein manner (i.e., it calculates the number of letters/digits that must be exchanged before one string is equal to another). We force the Levenshtein process to consider only addresses with exactly identical postcodes. Municipalities are combinations of several postcodes. By restricting to the same postcode, we ensure that the Levenshtein process cannot change the municipality information, the key information that we use to construct the disaggregated spending flows.

If the API cannot match the address unambiguously (so called C-match), we remove the first line of the address, which often combines abbreviations of merchant and street name, making it difficult to recognize automatically. We also check whether the address contains the name of a shopping mall, rather than an official address. If so, we replace the name of the mall with the mall's address and rerun the API process. Finally, we manually research the official address of the 100 most common unmatched addresses.

Using this procedure, we identify the official shop address for 95% of card and mobile spending. We assume that the remaining 5% go proportionally to the same regions as other card and mobile spending. These remaining 5% also include cases where mobile applications (e.g., MobilePay) and online services (e.g., PayPal) do not directly send the purchase amount to a sales terminal, but transfer to a central account first before paying the merchant.

For bill payments, we use a slightly different approach. We directly observe the merchant's postal code for recurrent bill payments, which make up 67% of all payments. These observed postal codes allow us to infer the merchant region for the majority of remaining bill payments. Specifically, we split merchants into 48 industries. We calculate the number of transactions from each consumer region going to each of these 48 industries. To minimize noise, we keep industries where at least 50% of incoming bill payments contain postal code information and where we observe at least 200 incoming transactions from every consumer region. (Industries receiving 80% of total bill transaction value satisfy these two requirements.) For these industries, we then assume that bill payments flow to the same postal codes as bill payments with observed postal codes from the same consumer region to the same industry. For the remaining industries (covering 20% of bill transaction value), we assume that bill payments flow to the same postal codes as card payments from the same consumer region to the same industry.

We generally do not observe how cash withdrawals are spent, but we assign them to merchants in proportion to observed card spending in Denmark if the withdrawal was in Denmark and to observed card spending abroad otherwise. In a few cases, country information is missing, so we assume that withdrawals without decimal points (e.g., 100.00 DKK) are withdrawn and spent in Denmark and that other withdrawals (e.g., 100.76 DKK) are spent abroad.

Appendix E.D Identifying the Merchant Industry

We observe the merchant category code (MCC), a classification for the type of goods sold by a merchant, in the bank transaction data. To create disaggregated economic accounts with consistently defined producer cells, we need to map MCCs to the industry codes used in the employment and trade data. However, no such mapping exists so far. We therefore create a new cross-walk between MCCs and NACE industries.

First, we observe each merchant's Danish business identification number (CVR) and MCC in the bank's system. We link the CVR to the Danish Central Business Register where we can retrieve the merchant's industry (at the level of 741 NACE codes). Second, we manually assign MCCs to our 31 industries (only 14 of which are consumer-facing and are assigned MCCs). We then identify which of our industries appear most frequently among merchants in each of the 741 NACE codes. In very few cases, two industries appear equally often and we manually research the largest firms to identify the best match.

We create an alternative mapping between a merchant classification system called PCAT and our industries. The PCAT usually appears as part of the electronic transaction information for bill payments and can easily be mapped to our industries. MCC and PCAT are missing for some bill payments, amounting to 8% of total transaction value through bills. We assume that these payments go proportionally to the same industries as other bill payments by the same consumer cell.

We censor information for cell-to-cell flows based on fewer than 10 transactions in total, which overall is relevant for less than 0.1% of national spending. We instead impute these flows, setting them equal to the average per capita spending flows of all other cells in the same region.

Appendix E.E Online Spending

We identify whether card transactions took place in a physical store or online. Dankort transactions include a straightforward binary indicator for online transactions. MasterCard and Visa transactions contain ISO 8583 information, an internationally standardized message sent by a sales terminal in a transaction. If the POS7 code (input method) equals 1, 6, K, or L or if the POS5 (cardholder) code equals 5, the transaction is online. We treat payments using mobile applications (e.g., MobilePay) and online services (e.g., PayPal) that do not report a physical merchant ID and address as online transactions. For digital payment services, such as PayPal and DoorDash, we typically see the correct MCC of the establishment receiving the final sales.

In constructing the disaggregated spending flows, we generally treat online spending identically to spending in a physical store. That means that we identify the region-industry cell of the merchant and assign the incoming spending to this cell. However, we adjust the regional (but not the industrial) distribution of online spending for industries where we know that consumption of the final good takes place entirely in a physical location. In these cases, we assign all online spending using the regional distribution of spending on physical merchants. The online spending on these industries often goes to the central payment terminal of a parent company before being assigned to the physical merchant. For instance, online purchases of cinema tickets are often booked through a central company terminal in Copenhagen, even though consumption happens in local movie theaters. The full list of industries where we adjust the regional distribution is: food away from home; entertainment; medical and other specialized merchants; commuting; vehicle repair; hotels; rental cars; home improvement services. (These industries are sub-categories of our 31 final industries.)

We verify that the distribution of merchants receiving spending is in line with the distribution of where workers are employed in Figure A.III, which validates the disaggregated spending data. We make one final adjustment to the disaggregated spending flows: we adjust spending on airlines flowing into Copenhagen because we know that the airline establishments receiving the spending are actually located in the neighboring Tårnby region, which also contains the airport. Specifically, we reassign a share of each consumer cell's spending on airlines flowing into Copenhagen to airlines in Tårnby, so that Copenhagen's share in airline spending received equals its share in airline employment.

Appendix E.F Improving the Spending Flows with Government Data

Consumer spending on four types of goods are not captured well in bank transaction data: housing, financial services, vehicles, and water and waste services. We replace the transaction-based values for these four goods in the disaggregated spending flows with adjusted values derived from combining Danske Bank data with government registers.

Appendix E.F.1 Consumption of Housing

We use separate methods to assign spending on owner-occupied housing and rented housing. First, owner-occupied rents are notoriously difficult to measure because they involve no financial transaction. However, the administrative income register (IND) contains the imputed rental value of owner-occupied housing for every individual. We thus allocate the national consumption of owner-occupied housing to consumer cells in proportion to the imputed rental value of their owner-occupied housing. Expenditure on owner-occupied housing flows to the producer cell for owner-occupied housing (our industry number 30) located in the same region as the home owners. The operating surplus of an owner-occupied housing producer cell in a region (SNA B.2G) then goes back to the consumer cells owning homes in that same region.

Second, we do not observe all rental payments in the bank transaction data. We instead distribute the national consumption of rented housing across consumer cells in proportion to their estimated rental costs. We observe some rental payments in the bank data, which we use to estimate

$$rental\ payment_p = \alpha + \vartheta\, region_p + \phi\, industry_p + \psi_1\, age_p + \psi_2\, age_p^2 + \varepsilon_p, \qquad \text{(A.1)}$$

where p is an individual renter. Using the estimated fixed effects ϑ and ϕ, we predict the average rental cost in each consumer cell. We observe ownership of real estate in the administrative income register (IND) and assume that all consumers who do not own real estate are renters, which allows us to calculate the number of renters by consumer cell. Combining estimated rental payments with the number of renters allows us to estimate total rental costs by consumer cell, which we use to allocate national consumption of rented housing across cells.

Finally, we use aggregate statistics to assign rental payments to producer cells. In the National Housing Statistics (Table BOL101), we observe the number of rental housing units in each region owned by different owner types: individuals, non-profit building societies, limited liability companies, housing societies, and public authorities. The surplus of individual owners accrues to the "private landlord" industry (our industry number 29) and the surplus of corporate owners accrues to the "finance, real estate" industry (our industry number 17). As there is no information about the geographical location of the owners, we assume that the geographical distribution of individual owners of rental units in a given region follows the geographical distribution of mixed income in the region and that the geographical distribution of the individuals behind corporate owners of rental units in a given region follows the geographical distribution of dividend payments. The remaining owner types are public or non-profit organization. The surplus of these owners goes to the "government-owned housing" industry (our industry number 31) in the same region where the housing is located.

Appendix E.F.2 Consumption of Financial Services

Consumption of financial services in the national accounts is composed of the value of financial advice provided by financial firms and the interest rate spreads accruing to financial firms. While we observe payments for financial advice in the bank transaction data, it is difficult to disentangle the interest rate spreads from the raw value of interest payments in transaction data. Instead, we allocate the national consumption of financial services across consumer cells in proportion to their interest expenses. The tax register (IND) contains interest expenses for every individual. We aggregate interest expenses at the level of each consumer cell.

Producer cells in our "finance, real estate" industry (number 17) receive consumers' expenditures on financial services. To identify which regional producer cells receive expenditures from which consumer cells, we use loan-level data from the administrative credit register (URTE). Specifically, for each bank loan and each interest payment, the credit register contains an identifier for the bank branch that has recorded the loan and the interest payment. There are around 3,000 bank branches in Denmark. We do not observe the region of branches directly, so we define the region of each branch as the most common region of consumers holding loans recorded at the branch. We then compute how the interest payments of each consumer cell are distributed across bank branches in different regions. Finally, we assume that a consumer cells' expenditure of financial services is distributed across producer cells in proportion to its distribution of interest payments.

Appendix E.F.3 Vehicle Purchases

We do not observe all vehicle purchases in the bank transaction data because many purchases do not flow directly to the vehicle producer but rather flow through financial firms. We therefore use a top-down approach to assign national vehicle purchases to consumer cells in proportion to each consumer cell's share of total spending on new cars. We estimate each consumer cell's total spending on new cars by combining bank transaction data on annual spending at vehicle dealers with information on vehicle registrations from the administrative auto register (DMR). We use data over the period 2014–2016, as this is the most recent period where we can combine transaction data from Danske Bank and administrative data from the auto register. We therefore assume that relative levels of vehicle spending are unchanged between 2014–2016 and 2018.

We first estimate the average price of purchased vehicles for each consumer cell. We use a sample of individuals where we observe just one new car registration in a given year and spending at vehicle dealers of at least 50,000 DKK in the bank transaction data in the same year. We then regress individual-level spending at vehicle merchants on industry-by-year and region-by-year fixed effects,

$$spending_{p,y}^{vehicle\_merchants} = \theta_{i(p),y} + \eta_{r(p),y} + \epsilon_p,$$

where p is an individual in industry $i(p)$ and region $r(p)$ and year is y. We predict the average price of new cars in each consumer cell using the estimated fixed effects. We can directly calculate the number of newly registered vehicles in the government vehicle registers. Combining the estimated price with the number gives an estimate of total spending on new cars by consumer cell for each year in 2014–2016. We compute each cell's share of total spending on new cars in each year and then average across years. We use these shares to allocate national vehicle purchases in 2018 across consumer cells.

Producer cells in our "cars, fuel, car repair, public transport" industry (number 5) receive consumers' expenditures on vehicles. To identify which regional producer cells receive spending from which consumer cells, we use Danske Bank data on vehicles purchased via cards, assuming that all consumers within the same region distribute their vehicle spending across regions in the same proportion.[A2]

Appendix E.F.4 Water and Waste Services

Rental payments often include consumption of water and waste services in Denmark, which implies that we cannot separately identify spending on water and waste in the transaction data. We therefore allocate the national consumption of water and waste services to consumer cells in proportion to their spending on other utilities. We assume that water and waste is produced locally, setting the region of the producer cell receiving the payments equal to region of the consumer cell.

Appendix F Measuring Disaggregated Product and Production-Related Taxes

Product taxes (SNA D.21) are paid by buyers upon the purchase of a good to the government. The most important product taxes are import taxes, product-specific taxes (e.g., on fuel, energy, cigarette, and alcohol), and valued added taxes (VAT).

We first describe how we measure import and product-specific taxes paid by consumers. (We turn to VAT later.) We observe the aggregate of import and product-specific taxes in the Danish national accounts table NIO3. The table reports aggregate import and product-specific taxes paid by consumers on the products of 117 distinct industries. These 117 industries do not map directly into our 31 industries. We therefore break down the 117 industries into the most granular grouping

[A2] If there are less than 50 vehicle car purchases in a region, we group that region with a neighboring region. This leads us to group Læsø with Frederikshavn; Langeland and Ærø with Svendborg; Fanø with Esbjerg; Ringkøbing-Skjern with Herning; Lemvig with Holstebro; Morsø with Thisted; and Samsø with Odder.

in the Danish national accounts (741 industries), by assuming that taxes paid on each industry's products are proportional to industry employment shares, and subsequently aggregate to our 31 industries. We then calculate the implied product-specific tax rate and the implied import tax rate for each of our industries by combining information on total tax-inclusive consumer spending on each industry from the disaggregated consumer spending flows with the tax data. The implied import and product-specific tax rates range from 0% in exempt industries (e.g., personal services, pharmacies and cultural and social organizations) to 50% in utilities (due to Denmark's very high energy tax rates).

We next describe how we measure VAT paid by consumers. The standard VAT rate in Denmark is 25%. We set this tax rate for consumer spending on all industries except a few industries whose products are VAT-exempt: airlines, finance, health, education, public administration, and all housing. In addition, spending on two of our industries is partially exempt: insurance (part of our industry 8, telecommunication and insurance) and culture (part of our industry 18 cultural and social organizations). We use data from NIO3 on total VAT paid by consumers on products of each industry, following the method used for product-specific and import taxes described above, and calculate that the average VAT rate is 7% (for industry 8) and 5% (for industry 18).

We disaggregate product taxes paid by Danish producers, the government, and the capital accumulation cell using the Danish input-output table, as described in Appendix M. Note that producers are reimbursed for VAT paid on intermediates.

We observe the net of production-related taxes (SNA D.29) and subsidies (SNA D.39) in the industry-level national accounts (summing positions in the national accounts of the financial, non-financial, and unincorporated household production sectors). Examples of such positions are a special payroll tax on firms in the financial industry, which compensates for the industry's VAT exemption; subsidies to agricultural producers; and housing property taxes. We take a top-down approach to allocating these industry-level flows to producer cells. For all industries except owner-occupied housing, we allocate the industry's net production-related taxes in proportion to labor compensation, which we compute from the employment register (BFL). For owner-occupied housing, we allocate net production-related taxes in proportion to their total rental value, which we compute from the income register (IND).

Appendix G Measuring Disaggregated Non-Product Taxes

Consumer non-product taxes are flows from consumer cells to the government. There are two types: current taxes on income, wealth, etc. (SNA D.5) and social contributions (SNA D.61).

First, current taxes on income, wealth, etc. include income taxes paid directly by consumers as well as a tax on pension wealth returns paid by pension funds on consumers' behalf. We disaggregate each part separately. In the income register (IND), we observe total annual income taxes paid, excluding pension returns taxes, for each individual in the population. We scale this measure by a factor 1.09 to match the national accounts aggregate when summing the values at the level of consumer cells. For the pension returns taxes paid by pension funds, we have no direct individual-level measure. We therefore apply a top-down approach assuming that DKK pension wealth returns, and hence also returns taxes, are proportional to total accumulated pension contributions since 1995, which is the first year for which we have microdata on pension contributions in the pension contribution register (INPI).

Second, we use a bottom-up approach to disaggregate social contributions. In the income register (IND) and the pension contributions register (INPI), we observe total annual pension contributions, including contributions to a mandatory retirement savings program (ATP), as well as on membership fee payments to unemployment insurance funds. We aggregate these variables to the cell level and scale the cell totals by a factor of 1.2 to make the national total match the national accounts aggregate.

Producer non-product taxes (SNA D.5) are paid on income and flow from producer cells to the government. Since income taxes in Denmark are a fixed fraction of producer profits, we allocate the national aggregate in proportion to the accounting profits of each producer cell (sales minus intermediates minus labor compensation).

Appendix H Measuring Disaggregated Consumer Interest and Transfers Paid

We disaggregate interest payments (SNA D.41) using a bottom-up approach. In the administrative income register (IND), we observe each individual's interest payments on all financial liabilities. The sum of these interest payments exceeds the value of position D.41 in the national accounts because the individual-level measure includes the full nominal amounts paid by consumers to lenders, whereas the national accounts value is net of Financial Services Indirectly Measured (FISIM). We therefore scale the individual-level variable so that its aggregate matches the national accounts. The implicit assumption is that the ratio of FISIM to total nominal interest payment is the same across consumer cells.

Since we have no individual-level data on payments related to renting of land and subsoil resources (SNA D.45), we use a top-down approach to disaggregate this flow. Each consumer cell is assigned a share of the aggregate value corresponding to its population share in the population register (BEF).

Other current transfers (SNA D.7) include non-life-insurance premium payments and miscellaneous current transfers. We also disaggregate these transfers top-down, assigning each cell a share of the national total equal to its population share.

Appendix I Measuring Disaggregated Labor Compensation

We use the income register (IND) and the pension contributions register (INPI) to measure total annual labor compensation, including employer contributions to pension schemes, paid to each individual consumer. We then aggregate these payments at the level of consumer and domestic producer cells. The aggregate of the raw disaggregated flows is slightly lower than in the national accounts, mostly because our sample contains only adults. We scale each value by a factor of 1.01 to match the national accounts flow compensation of employees, receivable (SNA D.1).

We also observe labor compensation received from foreign producers in the income register (IND). The aggregated value in the income register is below the aggregate in the national accounts, likely because our consumer cell definition implies that we do not capture individuals moving to Denmark during the year and because we do not observe foreign pension income perfectly in the income register. As a result, we scale each value by a factor of 1.47 to match the national accounts aggregate.

Finally, we record labor compensation paid by Danish producers to foreign employees. The employment register (BFL) contains all labor compensation payments by Danish producers and the unique personal identifier of the employee receiving the payment. We consider recipients not listed in the population register (BEF) as foreign employees. We scale the value of payments to foreign employees for each producer cell by a common factor of 1.14 to match the national accounts aggregate.

Appendix J Measuring Disaggregated Mixed Income, Dividends, and Surplus

We measure mixed income, dividends, and surplus flowing from each producer cell to each consumer cell.

Non-corporate firms pay mixed income to their owners. We determine how mixed income is distributed across consumer cells following the methodology for labor compensation discussed above. We link information about establishments operated by sole proprietorships from the employment register (IDAN), including the municipality where the establishments are located, to the mixed income of the individuals owning the establishment.

Corporate firms pay surplus to their owners in the form of dividends. To distribute dividend payouts across consumer cells, we rely on individual-level data on stock dividend income from the income register (IND). We disaggregate aggregate distributed income of corporations, receivable (SNA D.42) in proportion to the total dividend income of each consumer cell. We thereby implicitly assume that all consumer cells hold a diversified portfolio of Danish corporations. We measure dividends paid by each producer cell by distributing the aggregate dividends paid to Danish consumers in proportion to the accounting profits of each producer cell, which are measured in the disaggregated accounts as: total sales − intermediates − labor compensation − mixed income − surplus − dividends and surplus paid to government − net taxes − imports.

Finally, the national accounting flow operating surplus, gross (SNA B.2G) corresponds to operating surplus from owner-occupied housing. We aggregate individual-level imputed rental values of owner-occupied housing as reported in the income register (IND), which produces the industry's total output. We scale this output by a factor 0.67 to match the national value for B.2G. The implicit assumption is that the ratio between gross operating surplus and output in the owner-occupied dwellings industry is constant across consumer cells.

Appendix K Measuring Disaggregated Government Benefits to Consumers

National accounts describe three types of transfers to consumers. First, we aggregate all government income transfers and private pension savings payouts from the income register (IND) to calculate the cell-level measure of social benefits other than social transfers in kind (SNA D.62). We scale by a factor of 1.03 to match the national accounts value. Second, other current transfers (SNA D.7) consist of miscellaneous current transfers, for example, disaster and accident relief. We disaggregate this position top-down using cell population shares obtained from the administrative population register (BEF). Third, adjustment for the change in pension entitlements (SNA D.8) represents an accounting adjustment in the national accounts to avoid double-counting changes in pension entitlements.[A3] We disaggregate it by combining data from the income register and the pension contributions register (INPI) to construct an individual-level measure of pension contributions net of payouts. We then scale this measure to match the national accounts aggregate value.

Appendix L Measuring Disaggregated Consumer Interest and Transfers Received

First, we disaggregate interest, receivable (SNA D.41) bottom-up by using individual-level information on interest income from the income register (IND) and scaling so that the total across consumer cells matches the national accounts aggregate. Second, other investment income, receivable (SNA D.44) includes investment income from insurance policies and pension entitlements. We disaggregate this using a top-down approach where each consumer cell is assigned a share of the national accounts value proportional to its pension contributions accumulated since 1995.

[A3] In our system, all pension-related flows (SNA D.61, D.62, and D.8) originate and go to the government cell, which has the advantage that all double-counting of pension flows naturally nets out in the government cell. Aggregate national accounts in different countries deal with pensions in different ways. In the Danish national accounts, pensions flow between consumers and government as well as between consumers and the financial corporation sector, which creates the double-counting issue.

Third, rent, receivable (SNA D.45) consists of income from renting land and subsoil resources. We disaggregate it top-down using population shares.

Appendix M Measuring Disaggregated Intermediates Trade

Disaggregated intermediates trade flows describe how producers in one cell are connected to producers in other cells through trade in intermediates. We start from the Danish input-output table at the most disaggregated level with 117 industries (Tables NIO1, NIO2, and NIO3 at statbank.dk). The input-output table illustrates how the output produced by one industry is used as intermediate input in other industries or in final use categories, such as government spending and capital formation. It also shows how output from a given industry is produced from intermediate inputs acquired from other industries.

To convert the standard input-output table to a format suitable for our purposes, we need to address three challenges. First, the 117 industries do not map directly onto the industry classification used in the disaggregated economic accounts (DEA). Second, the input-output table has no geographical dimension: it describes flows from firms in industry s to firms in industry t at the national level, but not from firms in industry s and region i to firms in region j and industry t. Third, the national accounting convention of measuring output of retail industries in the form of net trade margins is not compatible with the disaggregated consumer spending flows (which reports actual money flows). The following subsections describe how we overcome these challenges.

Appendix M.A Adapting the IO table to DEA Industry Classification

To address the first challenge, we disaggregate the input-output table based on the national accounts (NA) industry classification to a more granular subindustry grouping. Formally, let lower-case letters $\{a, b, c...\}$denote the NA industries in the standard input-output table and let upper-case letters $\{A, B, C...\}$ denote the 27 output-producing DEA industries shown in Table A.I. Let j denote a granular industry at the level used in the microdata. Consider a particular NA industry $x \in \{a, b, c...\}$ and a particular DEA industry $Y \in \{A, B, C...\}$: we define subindustry x_Y as the set of granular-level industries that are subindustries of both x and Y, $x_Y = \{j | j \subset x, j \subset Y\}$. This approach produces 173 non-empty subindustries, which represent the highest level of industry aggregation compatible with both the NA classification and the DEA classification.

To carry out the disaggregation into subindustries, we compute a measure of output for each establishment by distributing the output of each firm across the establishments of the firm, using the within-firm labor compensation share of each establishment as weight. We then aggregate output to the level of each subindustry x_Y, compute the subindustry's output share within NA industry x, and disaggregate the flows for industry x reported in the original input-output table using these shares. For example, the original input-output table reports the value of flows from NA industry a to NA industry b. We assume that the flow stemming from subindustry a_Y is proportional to the share of output produced by NA industry a. Similarly, we assume that the flow to subindustry b_Z is proportional to its share of output in NA industry b. Concretely, we compute the flow from a_Y to b_Z as the total flow from a to b multiplied by the output shares of a_Y and b_Z within their respective NA industries.

The input-output table also reports flows from domestic final use categories (government spending, capital accumulation) to domestic producers and from domestic producers to the government in the form of VAT and product tax payments. We disaggregate these flows to the subindustry level on the producer side using subindustry output shares.

In sum, these steps produce a national table of trade flows at the level of 173 subindustries. We will later re-aggregate the 173 subindustries to the 27 output-producing industries in the DEA. However, before doing so, we add a regional dimension, as described next.

Appendix M.B Estimating the Role of Distance

We incorporate the effect of distance on intermediates trade using transaction-level data on producer-to-producer sales. The dataset is from the business service provider CrediWire and covers more than 4,300 firms over the period 2018-2022. The dataset includes information about industry and region of supplying firms retrieved from CrediWire's records. This allows us to assign each of the selling firms to a producer cell. When the buying firm is an identifiable domestic firm, the dataset also includes information about the industry and the region of the buying firm retrieved from the national business register. This allows us to assign each of these buying firms to a producer cell. The dataset covers around 5 million producer-to-producer transactions where both supplier and buyer can be assigned to producer cells.

We aggregate the transactions to the cell-level and estimate a gravity model, with the aim of estimating how producer-to-producer trade varies with distance. The dependent variable is sales from the selling (supplier) producer cell to the buying (user) producer cell and the key explanatory variable is geographical distance. The model also includes two sets of fixed effects. First, there are fixed effects for every producer cell, both on the supplier side and the user side, which control non-parametrically for the economic size of producer cells. Second, there are fixed effects for every pair of supplier industry and user industry, which ensures that identification comes exclusively from variation in geographical distance within industry pairs. We estimate the gravity model in its multiplicative form with the Poisson pseudo-maximum likelihood estimator (Silva and Tenreyro 2006).

The baseline model yields a statistically significant distance coefficient of around -0.74. This coefficient captures the average elasticity of domestic trade with respect to distance.[A4] Incidentally, it is close to analogous estimates for international trade (e.g., Silva and Tenreyro 2006 report an estimate of -0.78 in their Table 3, column 6). We next allow for heterogeneity in the distance coefficient by interacting distance with indicators for supply industries and use industries. This allows us to obtain an estimated distance coefficient for every combination of supply industries and use industries (576 estimates) by adding the coefficients on the relevant supply industry interaction and the relevant use industry interaction. Figure A.IV illustrates the results with two sets of box plots: Panels a and b show the distribution of distance coefficients (i.e., median, quartiles, and adjacent values) for each supply industry and for each use industry, respectively. The distance coefficients vary substantially across supply industries (and much less within) and within use industries (and much less across). This pattern is consistent with the notion that the structural elasticity is product-specific and that firms tend to use a large number of inputs to produce a small number of outputs.

Appendix M.C Combining Regional and Industry Variation

We determine the level of trade in each region-by-industry cell by assuming that regions send and receive intermediates in proportion to their shares of total labor compensation paid in each subindustry (except in the three zero-employment housing industries where we use regional spending shares from the disaggregated consumer spending flows, see Appendix E).

Combining this assumption on trade levels with the estimated distance coefficients, we can now disaggregate the flows between subindustries to a region-by-subindustry table. Formally, let a_Y and b_Z denote subindustries and let i and j denote regions. We assume that the flow from subindustry a_Y, region i to firms in subindustry b_Z, region j is

$$flow_{a_Y,b_Z,i,j} = flow_{a_Y,b_Z} * \theta_{a_Y,b_Z,i} * \eta_{a_Y,b_Z,j} * distance_{ij}^{-\beta^{IND(i)}-\beta^{IND(j)}}, \qquad \text{(A.2)}$$

where $flow_{a_Y,b_Z}$is the intermediates flow from subindustry a_Y to subindustry b_Z at the national level and $distance_{ij}$ is the distance between region i and region j. The parameters $\theta_{a_Y,b_Z,i}$ and $\eta_{a_Y,b_Z,j}$ are origin and destination region fixed effects within the a_Y-b_Z subindustry pair. These are set so that 1) region i's total share of national a_Y-b_Z flows (i.e., $\sum_j flow_{a_Y,b_Z,i,j}/flow_{a_Y,b_Z}$) matches its share of labor compensation payouts in subindustry a_Z, and 2) region j's total share of industry a_Y-b_Z flows (i.e., $\sum_i flow_{a_Y,b_Z,i,j}/flow_{a_Y,b_Z}$) matches its share of total labor compensation payouts in subindustry b_Z.

We implement this assumption through an iterative numerical procedure. Starting from initial

[A4] This average coefficient differs from the one reported in Figure IV because there we use a more traditional log-log specification without the pairwise supplier-by-user fixed effects, without zero flow and zero distance observations in the dataset, and without relying on the Poisson estimator.

guesses for $\theta_{a_Y,b_Z,i}$ and $\eta_{a_Y,b_Z,j}$, we compute the implied value of each $flow_{a_Y,b_Z,i,j}$. We then adjust the guesses by a multiplicative constant that ensures that the flows add up to their national counterpart, $flow_{a_Y,b_Z}$. Next, we update the guesses by multiplying them with the ratios of the regions' labor compensation shares to the implied shares of national a_Y-b_Z flows. We repeat this procedure until the implied share of national a_Y-b_Z flows converges toward the relevant labor compensation share for each origin and destination region.

For flows from final use categories (non-profits, government spending, capital formation) to domestic subindustries, we add a geographic dimension on the destination side only. Here, we assign each region a share of the total national flow equal to its share in subindustry labor compensation. Conversely, for VAT and product taxes going from domestic subindustries to the government, we add a geographic dimension on the origin side only: each region is assigned a share of the national flow equal to its labor compensation share within the subindustry.

After disaggregating to the subindustry-region level, we aggregate to the industry-region cell level described in Appendix D by summing over subindustries belonging to the same DEA industry within each region.

Appendix M.D Redirecting Flows From Consumers Through Retailers

National accounts measure output in retail industries as trade margins (i.e., sales net of acquisition costs). Thus, if a retailer buys a product from a non-retail producer at price p_1 and sells it to a consumer at price p_2, the national accounts input-output table will display two flows: 1) a flow of $p_2 - p_1$ from consumers to retail, and 2) a flow of p_1 from consumers to the non-retail producer's industry. This makes the standard input-output table inconsistent with our disaggregate spending flows because the disaggregated spending flows show total sales values going from consumers to producers. A consistent system of disaggregated economic accounts therefore necessitates an adjustment to make the different disaggregated datasets compatible.

Since the disaggregated economic accounts are measured in total sales units, we leave the disaggregated consumer spending flows untouched and instead adjust the disaggregated intermediates trade flows. Specifically, we identify flows in the national accounts input-output table that go directly from consumers to producer industries that, in fact, do not sell directly to consumers (see Table A.I). We set the original flow equal to zero and instead add it in two places: first, to the flow going from consumers to the retail industry that sells the relevant goods; and second, to the flow going from the relevant retail industry to the industry producing the good. With that adjustment, the producing industry still receives the same amount of inflows, while consumers still spend the same amount. The only difference is that the relevant retail industry now has higher inflows (from consumers) and outflows (to the producing industry). We identify the relevant industry by manually assigning the 72 consumption categories reported in the input-output tables to the retail industry most likely to sell that category.[A5]

Note that this adjustment increases the total sum of flows in the input-output table. For retail industries, the total sum of inflows thus no longer corresponds to the total value of output as defined in national accounts. The output of retailers is now defined as the full value of sales (excluding VAT and product taxes), while the retailer's acquisition cost is treated as an intermediate input from the non-retail producer of the traded product.

Appendix N Measuring Disaggregated Exports and Imports

Appendix N.A Foreign Exports and Imports of Manufacturing Firms

We follow different methods for manufacturing and non-manufacturing firms. For manufacturing firms, we observe imports and exports at the level of individual firms (CVR level) in two databases. Trade in goods is in the foreign trade registry (UHDI), while trade in services is in the firm sales and purchases registry (FIKS). We calculate each firm's total exports and imports as the sum of the values in the two registries.[A6] In some industries, the firm-level data and national accounts do not follow the same reporting guidelines for exports and imports. For instance, Danish national accounts report exports and imports of electricity traders by netting out short-run off-setting trades, while firm data report gross values. To ensure that we report values in line with national accounting guidelines, we scale total exports and imports in the firm-level data to match the industry aggregates in the national input-output table, at the level of 117 industries.

The vast majority of firms have only one establishment. We therefore assign these firms' exports and imports to their unique region-industry cell. For multi-establishment firms, we use information on the occupations of workers in each establishment to distribute firm exports and imports. We allocate exports of manufacturing firms to an establishment in proportion to the share of manufacturing workers' labor compensation paid by that establishment (relative to the firm's other establishments). We define manufacturing workers as those with occupation codes 13, 21, 31, 60--62, 70–75, 80–83, and 90–97. For instance, if a manufacturing firm has three establishments but one employs no manufacturing workers and two pay the same total labor compensation to manufacturing workers, we would assume that the exports of that firm come in even measure from

[A5]An example illustrates how the adjustment affects the final intermediates trade table. If the input-output table reports a flow of 1,000 from private consumers to manufacturers in region X as payment for cheese, the disaggregated intermediates trade flows replace this flow of 1,000 with 1) flows from grocery retailers in each of the 98 regions to manufacturers in region X, where the size of each flow is 1,000 multiplied by the origin region's share in total existing flows from grocery retailers to manufacturers in region X; and 2) flows from private consumers to grocery retailers in each of the 98 regions, where the size of each flow matches the corresponding retailer-to-manufacturer flow.

[A6]For exports to non-EU countries, the FIKS registry shows only the sum of goods and services exports. We calculate services exports separately by assuming that the ratio of services to goods exports is the same for EU and non-EU exports at each firm.

the two establishments employing manufacturing workers. For imports, we allocate imports to an establishment in proportion to the share of firm-level non-retail store workers' labor compensation paid by that establishment.

Once we have allocated imports and exports of manufacturing firms to establishments, we assign each establishment to an industry-region cell, as described in Appendix D, and aggregate to the cell level.[A7]

Appendix N.B Foreign Exports and Imports of Non-Manufacturing Firms

We disaggregate exports and imports of non-manufacturing firms using labor compensation shares of regions within fine industries (based on the finest Danish classification at the level of 173 industries).

One industry (owner-occupied housing) has no firms, yet still has a small amount of imports according to the national accounts. We disaggregate this amount to the industry-region level using the geographic distribution of the imputed rental value of owner-occupied housing from the income register (IND).

Following the method applied to the disaggregated intermediates trade flows, we adjust the imports of retail industries to ensure consistency with the disaggregated consumer spending flows (see Appendix M.D).

Appendix N.C Exports to Foreign Visitors in Denmark

Firms can also export by selling goods to foreign consumers while they are in Denmark (e.g., sales to foreign tourists in Denmark). The national input-output table reports the total amount of consumer spending by foreign residents on Danish producers. We disaggregate this amount across Danish producer cells using two data sources.

First, we use the industry distribution of Danish residents' spending abroad from the disaggregated consumer spending flows to compute a proxy for each industry's share of foreign tourist spending, thus assuming that Danish tourists' spending behavior in foreign countries is indicative of foreign tourists' spending in Denmark. Second, to distribute across regions, we use data from visitdenmark.dk on foreigners' overnight stays at hotels to compute a proxy for each region's share of foreign tourist spending.

[A7]To conform with anonymity guidelines, we censor exports and imports for cells with less than five firms and for cells where two firms represent more than 85% of total firm turnover. Within each industry, we compute total exports and imports associated with the censored cells and distribute it across the censored cells in proportion to their within-industry labor compensation shares.

Appendix O Measuring Disaggregated Government Dividend and Surplus Income

The government receives income from each producer cell that contains some government-owned establishments. We start with a list of firms that sell to consumers and producers at market prices and are (full or partly) owned by the government.[A8] We manually collect annual turnover for every firm from annual reports. We also collect information on establishment-level employment from the Danish business register (CVR). We combine these two datasets and split annual turnover regionally using each firm's distribution of employment across regions. We finally aggregate across industries (using the industry code of the parent firm) and regions to get to our level of producer cells. We assume that the share of surplus received by the government is equal to the share of turnover by government-owned establishments in each producer cell.

Appendix P Measuring Disaggregated Producer and Government Net Interest, Transfers, and Saving

The analog to producer net interest, transfers, and saving in the aggregate national accounts is the sum of the following SNA positions in the financial and non-financial corporate accounts: interest paid − received (net of D.41) + reinvested earnings on direct foreign investments other current transfers paid − received (net of D.43) + other investment income paid − received (net of D.44) + other current transfers paid − received (net of D.7) + natural resource rents paid (D.45) + gross saving (B.8g) + distributed income of corporations paid to rest of world (part of D.42) − distributed income of corporations received (D.42). This sum, based on the aggregate national accounts, differs slightly from "producer net interest, transfers, and saving" in our disaggregated accounts because the disaggregated spending flows imply a slightly higher value for consumer spending on foreign producers and thus slightly lower sales of domestic producers. An advantage of our approach is that we can directly observe foreign spending by Danish consumers in the Danske Bank data. In contrast, national accounts rely on balance of payments statistics, retail turnover, and consumer surveys to determine foreign spending (see also Footnote 10).

The analog to government net interest, transfers, and saving in the aggregate national accounts is the sum of the following government SNA positions: interest paid − received (net of D.41) + other current transfers paid − received (net of D.7) + gross saving (B.8g) − other investment income (D.44) − natural resource rents received (D.45). However, this sum based on the aggregate national accounts does not equal "net interest, transfers, and saving" in our disaggregated accounts because we do not disaggregate taxes, benefits, and subsidies received by institutional sectors other than

[A8] See fm.dk/arbejdsomraader/statens-selskaber/organisering.

producers and consumers (see Section IV.B).

Appendix Q Measuring Disaggregated Consumption of Government and NPISH Output

We measure which consumer cells consume different types of government services. In the system of disaggregated economic accounts, the government purchases these services from government-operated establishments in each producer cell and provides them to consumers free of charge. We assume that the per capita consumption of collective public goods is uniform across the Danish population (including police, national defense, and public administration). We use individual-level data on actual uses of public services to allocate individual public consumption (including education, healthcare, and social protection), as detailed below.

Appendix Q.A Education

We assign the aggregate consumption of education services observed in the national accounts to consumer cells according to the number of students in primary, secondary, and tertiary education in a cell. The education register ("UDD") contains information about the education program in which each individual is currently enrolled (if any) as well as each individual's highest completed education. We categorize individuals as primary school students if they are currently enrolled in a program and have no completed education; as secondary school students if they are currently enrolled in a program and their highest completed education is primary school (10 years); as tertiary education students if they are currently enrolled in a program and their highest completed education is secondary school (13 years); and as non-students if they are currently not enrolled in a program.

We aggregate the number of students in primary, secondary, and tertiary education to the level of consumer cells. As the cells only include the adult population, we assign the education consumption of minors to adults in the same household before aggregating, drawing on the intra-household links in the population register (BEF). For instance, two parents with three children, two of whom are in primary school and one of whom is in secondary school, would each consume the equivalent of one year of primary education and half a year of secondary education.

Finally, we allocate aggregate government spending on education to cells in proportion to their share of students in primary, secondary, and tertiary education and total government expenditure on education at each of these levels. Specifically, the estimated consumption of education services in cell i is

$$C_i^{edu} = \sum_{q=p,s,t} \frac{\#students_{i,q}}{\#students_q} \times expenditure_q,$$

where q is the level of education (with p, s, and t indicating primary, secondary, and tertiary, respectively) and expenditure is government spending on education of level q.

Appendix Q.B Healthcare

Government spending on healthcare falls into six categories: outpatient services; hospital services; medical products, appliances and equipment; public health services; research and development; and other. We allocate government healthcare consumption summed over all six categories, as reported in national accounts, to consumer cells using publicly available statistics for the first two categories, which make up around 85% of the total.

Outpatient services capture government spending flowing to primary healthcare providers, like general practitioners, specialist doctors, psychiatrists, and dentists. We obtain average primary healthcare expenditures by age, gender, and municipality (Table SYGU1 in the Public Expenditure Statistics). Based on a regression of average primary healthcare expenditure on a set of indicators for age, gender, and municipality, we predict primary healthcare expenses for each individual in the population. We then aggregate the predicted expenditures to the level of consumer cells. Since children account for a non-negligible part of healthcare spending, we include the full population by assigning minors to the same consumer cells as the adults cohabiting with the child. If parents live together but work in different industries, we split the child's predicted healthcare expenditure equally between the two cells.

Hospital services capture government expenditure related to hospital treatments, including emergency room and outpatient hospital treatments. Again, we obtain information on the average number of days spent in hospital by age, gender, and municipality (Table INDAMP01 in the Health Statistics). Regressing average hospital days on a set of indicators for age, gender, and municipality, we predict the number of hospital days for each individual in the population. We then aggregate the predicted hospital days to the consumer cell level, again allocating the hospital days of minors to their parents' cells.

Finally, we combine the two indicators of healthcare usage to disaggregate total consumption of healthcare services of consumer cell i as

$$C_i^{health} = \sum_{q=o,h} \left(\frac{usage_{i,q}}{\sum_i usage_{i,q}} \times \frac{exp_q}{exp_o + exp_h} \right) \times exp, \tag{A.3}$$

where q indexes the type of healthcare (with o and h indicating outpatient and hospital services, respectively), $usage_{i,q}$ denotes cell *i's* usage of type q (expenditure on primary care and the number of hospital days), exp_q is national government spending on healthcare of type q, and exp is national government spending on healthcare summed over all six categories.

Appendix Q.C Social Protection

Government spending on social protection falls into five categories: sickness and disability; old age; family and children; unemployment; and other. We allocate social protection services to consumer cells based on government microdata. Specifically, we allocate the category "sickness and disability" to cells in proportion to the number of individuals on sick leave or disability pension as observed in the income register (IND); the category "old age" in proportion to the number of individuals aged 80 or older as observed in the population register (BEF); the category "family and children" in proportion to the number of preschool children as observed in the population register (BEF); the category "unemployment" in proportion to the number of unemployed; and the category "other" by population shares. The estimated consumption of social protection services in consumer cell i is thus

$$C_i^{social} = \sum_{q=s,o,d,u,z} \frac{usage_{i,q}}{\sum_i usage_{i,q}} \times exp_q, \tag{A.4}$$

where q indexes the type of social protection (with s, o, d, u, and z denoting sickness/disability, old age, family/children, unemployment, and other, respectively), $usage_{i,q}$ denotes the relevant indicator for cell i's usage of type q (see above), and exp_q is national government spending on social protection services of type q.

Appendix Q.D Measuring Disaggregated Consumption of NPISH Output

We measure the consumption of output provided by non-profit organizations (NPISH) for different consumer cells. NPISH output falls into five categories: education; social work activities; libraries; museums and other cultural activities; sports activities (non-market); and activities of membership organizations.

We first disaggregate usage of the first four categories by consumer region. For education, we use regional data on the share of children attending private schools relatively to public schools (Table "UDDAKT20" in the Education Statistics). For social work, we use regional data on the share of privately owned (as opposed to government-operated) daycare institutions (Table "BOERN4" in the Child Care Statistics). For libraries, we use regional data on library usage per capita (Table "BIB1" in the Culture and Leisure Statistics). For museums and other cultural activities, we use regional data on members of sports associations per capita.

To infer usage by industry of work, we rely on the Danske Bank data. For education, we proxy use of NPISH education with payments to private schools. For social work, we calculate payments to private child-care institutions. For libraries, we use payments to libraries. For sports activities, we use membership payments to sports associations. For all categories, we count the number of transactions relative to the number of bank customers in each industry. We thereby estimate how likely consumers in each industry are to consume a given type of NPISH output.

We combine the information on consumption shares of NPISH by consumer region and industry to calculate consumption of NPISH output by consumer cell:

$$npish^{q}_{r,i} = \sum_{q} \frac{npish_{q,r} \times npish_{q,i} \times pop_{r,i}}{\sum_{r,s} npish_{q,r} \times npish_{q,i} \times pop_{r,i}} \times expenditure_{q},$$

where q is the NPISH category, r is region, i is industry, $pop_{r,i}$ is the cell's population, and expenditure is national NPISH output of type q.

For the final type of NPISH consumption, activities of membership organizations, we rely on Danske Bank data. This category consists mostly of trade unions and a small component of political or religious organizations. We disaggregate national consumption using as weights the share of individuals making payments to trade unions in each cell multiplied by the cell's population.

Appendix R Details on Model Derivations

Appendix R.A Formula for change in GNE (15)

With welfare weights equal to inverse marginal utilities, the first order change in welfare is given by

$$\begin{aligned}
\sum_{i\in\mathcal{I}} P_i C_i \cdot dU_i &= \sum_{i\in\mathcal{I}} P_i dC_i + \sum_{i\in\mathcal{I}} \frac{P_i C_i}{G_i} \psi_i dG_i \\
&= \sum_{i\in\mathcal{I}} P_i dC_i + \sum_{i\in\mathcal{I}} \frac{\nu_i \cdot \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j G_j}{G_i} dG_i \\
&= \sum_{i\in\mathcal{I}} P_i dC_i + \frac{\sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j G_j}{v\left(\{G_j\}\right)} \sum_{i\in\mathcal{I}} dG_i \\
&= \sum_{i\in\mathcal{I}} P_i dC_i + \sum_{i\in\mathcal{I}} \mathcal{P}(\{P_j\}) dG_i \\
&= \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j dc_{ij} + \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} P_j dG_j \\
&= dGNE.
\end{aligned}$$

Appendix R.B Proof of Proposition 1

As explained in footnote 19 below Proposition 2, Proposition 1 is a simple special case of Proposition 2.

Appendix R.C Proof of Proposition 2

Network-adjusted export intensities. We begin by defining two measures of export intensity that will become useful later on. The first object, χ_j, captures the export intensity of a producer cell's output. In particular, it is the share of its output that is either directly exported, or sold to customer producers that export it, or sold to customer producers that sell it themselves to producers that export it, and so on. It is easiest to define the object recursively,

$$\chi_j \equiv \frac{P_j x_j}{P_j Q_j} + \sum_{j' \in \mathcal{J}} \frac{P_{j'} X_{j'j}}{P_j Q_j} \chi_{j'}. \tag{A.5}$$

The first term is producer j's own share of exports in output. The second term captures the higher-order effects: j's customers have some export intensity as well. It is trivial to see that (A.5) admits a unique, non-negative solution for χ_j by writing the system as a vector equation.

The second object, which we denote by χ_i with slight abuse of notation, captures the export intensity of consumer cell i's labor. We define it as

$$\chi_i \equiv \frac{\sum_{j \in \mathcal{J}} \chi_j N_{ij} + N_{i\mathcal{R}}}{N_i}. \tag{A.6}$$

This is best interpreted as a weighted average, with income shares as weights. Cell i earns a share $\frac{N_{ij}}{N_i}$ of its labor income from producer cell j, whose export intensity is χ_j. Hence, χ_j enters (A.6) with weight $\frac{N_{ij}}{N_i}$, for all domestic producers $j \in \mathcal{J}$. Cell i also potentially earns labor income in the rest of the world. In that case, it (effectively) has an export intensity of 1. Hence, a weight $N_{i\mathcal{R}}/N_i$ is placed on 1 in (A.6).

Real GNE. We begin the proof by consolidating the budget constraints of all domestic consumer cells and the government, that is, summing (5), (6), and (12). We obtain

$$\sum_{i \in \mathcal{I}} \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} P_j c_{ij} + \sum_{j \in \mathcal{J} \cup \{\mathcal{R}\}} P_j G_j = \sum_{i \in \mathcal{I}} N_i W_i + \sum_{j \in \mathcal{J}} \Pi_j^{pre} + \sum_{i \in \mathcal{I}} T_i^{ROW}. \tag{A.7}$$

We specifically allow for a transfer T_i^{ROW} from the rest of the world to consumer cell i. These transfers are zero in the initial equilibrium. The left-hand side of this expression is nominal gross national expenditure (GNE).

Consider now a small change in transfers $\{dT_i^{ROW}\}$, which may cause a change in prices $\{dP_j\}$, wages $\{dW_i\}$, and profits $\{d\Pi_j^{pre}\}$. We think of each transfer dT_i^{ROW} as going from the rest of the world to the government, funding a transfer from the government to consumer cell i of magnitude

$$(1-\overline{\tau}_i)\, dT_i = dT_i^{ROW}, \tag{A.8}$$

where $\overline{\tau}_i dT_i$ is the additional government revenue due to the transfer,

$$\overline{\tau}_i dT_i = \sum_{i\in\mathcal{I}} \tau_i dY_i + \sum_{j\in\mathcal{J}} \tau_j^{corp} d\Pi_j^{pre} + \sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} \tau_i^{vat} d\left(P_j c_{ij}\right).$$

Linearizing (A.7), we find the following expression for real GNE, as defined in (15),

$$dGNE = -\sum_{j\in\mathcal{J}\cup\{\mathcal{R}\}} dP_j \left(\sum_{i\in\mathcal{I}} c_{ij} + G_j\right) + \sum_{j\in\mathcal{J}} d\Pi_j^{pre} + \sum_{i\in\mathcal{I}} N_i dW_i + \sum_{i\in\mathcal{I}} dT_i^{ROW}. \tag{A.9}$$

We now simplify this successively.

Simplifying profits $\sum_{j\in\mathcal{J}} d\Pi_j^{pre}$. Using the budget constraint of producer cells, (8), we can express the change in profits as

$$\sum_{j\in\mathcal{J}} d\Pi_j^{pre} = \sum_{j\in\mathcal{J}} d\left(P_j Q_j\right) - \sum_{j\in\mathcal{J}} \sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} d\left(N_{ij} W_i\right) - \sum_{j\in\mathcal{J}} \sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} d\left(P_{j'} X_{j'j}\right). \tag{A.10}$$

Observe that

$$\begin{aligned}
\sum_{j\in\mathcal{J}} \sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} d\left(N_{ij} W_i\right) &= \sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} d\left(\sum_{j\in\mathcal{J}} N_{ij} W_i\right) \\
&= \sum_{i\in\mathcal{I}} d\left(\sum_{j\in\mathcal{J}} N_{ij} W_i\right) + d\left(\sum_{j\in\mathcal{J}} N_{\mathcal{R}j} W_{\mathcal{R}}\right) \\
&= \sum_{i\in\mathcal{I}} N_i dW_i + W_{\mathcal{R}} d\left(\sum_{j\in\mathcal{J}} N_{\mathcal{R}j}\right).
\end{aligned}$$

Substituting this into (A.10), we arrive at

$$\sum_{j\in\mathcal{J}} d\Pi_j^{pre} = \sum_{j\in\mathcal{J}} d\left(P_j Q_j\right) - \sum_{i\in\mathcal{I}} N_i dW_i - d\left(\sum_{j\in\mathcal{J}} N_{\mathcal{R}j} W_{\mathcal{R}}\right) - \sum_{j\in\mathcal{J}} \sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} d\left(P_{j'} X_{j'j}\right). \tag{A.11}$$

With (A.11), we simplify the change in real GNE in (A.9),

$$dGNE = -\sum_{j\in\mathcal{J}} dP_j \left(\sum_{i\in\mathcal{I}} c_{ij} + G_j + \sum_{j'\in\mathcal{J}} X_{jj'} - Q_j\right) + \sum_{j\in\mathcal{J}} P_j dQ_j - W_{\mathcal{R}} d\left(\sum_{j\in\mathcal{J}} N_{\mathcal{R}j}\right) - \sum_{j\in\mathcal{J}}\sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} P_{j'} dX_{j'j} + \sum_{i\in\mathcal{I}} dT_i^{ROW}. \quad \text{(A.12)}$$

Simplifying output changes $\sum_{j\in\mathcal{J}} P_j dQ_j$. With unitary elasticities, the production functions (7) are log linear. This implies that

$$d\log Q_j = \sum_{i\in\mathcal{I}\cup\{\mathcal{R}\}} \frac{N_{ij}W_i}{P_jQ_j} d\log N_{ij} + \sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} \frac{P_{j'}X_{j'j}}{P_jQ_j} d\log X_{j'j}.$$

We can sum and rearrange this to

$$\sum_{j\in\mathcal{J}} P_j dQ_j = \sum_{i\in\mathcal{I}} N_{i\mathcal{R}} dW_i + \sum_{j\in\mathcal{J}} W_{\mathcal{R}} dN_{\mathcal{R}j} + \sum_{j\in\mathcal{J}}\sum_{j'\in\mathcal{J}\cup\{\mathcal{R}\}} P_{j'} dX_{j'j}.$$

Again, we substitute this into our expression (A.12) for the change in real GNE,

$$dGNE = -\sum_{j\in\mathcal{J}} dP_j \left(\sum_{i\in\mathcal{I}} c_{ij} + G_j + \sum_{j'\in\mathcal{J}} X_{jj'} - Q_j\right) + \sum_{i\in\mathcal{I}} N_{i\mathcal{R}} dW_i + \sum_{i\in\mathcal{I}} dT_i^{ROW}.$$

With goods market clearing (14), this simply becomes

$$dGNE = \sum_{j\in\mathcal{J}} x_j dP_j + \sum_{i\in\mathcal{I}} N_{i\mathcal{R}} dW_i + \sum_{i\in\mathcal{I}} dT_i^{ROW}. \quad \text{(A.13)}$$

Simplifying export values $\sum_{j\in\mathcal{J}} x_j dP_j$. Next, we analyze $x_j dP_j$. From producers charging unit costs, we know that

$$d\log P_j = \sum_{i\in\mathcal{I}} \frac{N_{ij}W_i}{P_jQ_j} d\log W_i + \frac{\Pi_j^{pre}}{P_jQ_j} d\log \Pi_j^{pre} + \sum_{j'\in\mathcal{J}} \frac{P_{j'}X_{j'j}}{P_jQ_j} d\log P_{j'}. \quad \text{(A.14)}$$

To solve this fixed point, we adopt the notation that $\{\}$ with one index is a vector and with two indices is a matrix. For example, $\{d\log P_j\}_j$ is the vector of price changes or $\left\{\frac{P_{j'}X_{j'j}}{P_jQ_j}\right\}_{j,j'}$ is a matrix with intermediate input shares. Then, we solve (A.14) as

$$\{d\log P_j\}_j = \left(\mathbf{I} - \left\{\frac{P_{j'}X_{j'j}}{P_jQ_j}\right\}_{j,j'}\right)^{-1} \cdot \left\{\sum_{i\in\mathcal{I}} \frac{N_{ij}W_i}{P_jQ_j} d\log W_i + \frac{\Pi_j^{pre}}{P_jQ_j} d\log \Pi_j^{pre}\right\}_j .$$

This means,

$$\begin{aligned}\sum_{j\in\mathcal{J}} x_j dP_j &= \sum_{j\in\mathcal{J}} P_j x_j d\log P_j \\ &= \left\{\sum_{i\in\mathcal{I}} \frac{N_{ij}W_i}{P_jQ_j} d\log W_i + \frac{\Pi_j^{pre}}{P_jQ_j} d\log \Pi_j^{pre}\right\}_j' \cdot \left(\mathbf{I} - \left\{\frac{P_{j'}X_{j'j}}{P_jQ_j}\right\}_{j,j'}'\right)^{-1} \cdot \{P_j x_j\}_j .\end{aligned}$$

Here, notice that

$$\{P_jQ_j\chi_j\}_j = \left(\mathbf{I} - \left\{\frac{P_{j'}X_{j'j}}{P_jQ_j}\right\}_{j,j'}'\right)^{-1} \cdot \{P_j x_j\}_j ,$$

with χ_j defined as (A.5). Thus,

$$\sum_{j\in\mathcal{J}} x_j dP_j = P_jQ_j\chi_j \cdot \left\{\sum_{i\in\mathcal{I}} \frac{N_{ij}W_i}{P_jQ_j} d\log W_i + \frac{\Pi_j^{pre}}{P_jQ_j} d\log \Pi_j^{pre}\right\}.$$

After some rewriting, we find

$$\sum_j x_j dP_j = \sum_{i\in\mathcal{I}}\sum_{j\in\mathcal{J}} \chi_j N_{ij} dW_i + \sum_{j\in\mathcal{J}} \chi_j d\Pi_j^{pre}.$$

Substituting this into our formula (A.13) for $dGNE$, we obtain

$$dGNE = \sum_{i\in\mathcal{I}} \left(\sum_{j\in\mathcal{J}} \chi_j N_{ij} + N_{i\mathcal{R}}\right) dW_i + \sum_{j\in\mathcal{J}} \chi_j d\Pi_j^{pre} + \sum_{i\in\mathcal{I}} dT_i^{ROW}.$$

Using the definition for χ_i in (A.6), this finally becomes

$$dGNE = \sum_{i\in\mathcal{I}} \chi_i N_i dW_i + \sum_{j\in\mathcal{J}} \chi_j d\Pi_j^{pre} + \sum_{i\in\mathcal{I}} dT_i^{ROW}. \tag{A.15}$$

From this, the proposition follows directly. For a transfer dT_i^{ROW} to a single consumer cell i, we have

$$\frac{dGNE}{(1-\overline{\tau}_i)\, dT_i} = \frac{dGNE}{dT_i^{ROW}} = 1 + \sum_{i\in\mathcal{I}} \chi_i N_i \frac{dW_i}{(1-\overline{\tau}_i)\, dT_i} + \sum_{j\in\mathcal{J}} \chi_j \frac{d\Pi_j^{pre}}{(1-\overline{\tau}_i)\, dT_i},$$

where we used (A.8). This confirms (18).

Appendix R.D Model with Nominal Wage Rigidities

We next introduce a version of the model with nominal wage rigidities. We first describe its setup, then its equilibrium, and finally its calibration.

Setup. The model differs in two ways from the model introduced in Section VI. First, each consumer cell has flexible labor supply N_i, subject to disutility $\varphi_i \cdot v(N_i)$. That is, utility is now given by

$$U_i = \log C_i + \chi_i \log G_i - \varphi_i v(N_i).$$

Second, each consumer cell's nominal wage W_i is fixed at some level $W_i = \overline{W}_i$, in units of foreign currency.[A9] At this wage, the consumers in the consumer cell are required to accommodate any amount of labor demand.

Equilibrium. We define equilibrium as in any competitive model with flexible prices.

Definition 2. A *competitive equilibrium* in the economy consists of prices and wages $\{P_j, W_i\}$ and an allocation $\{Q_j, N_{ij}, X_{j'j}, \Pi_j, T_i, G_j, Y_i, c_{ij}, x_j\}$ such that (a) the wage is fixed at $W_i = \overline{W}_i$; (b) income is given by (5); (c) all consumer cells maximize utility (4) subject to (6) and supply labor in line with labor demand, $N_i = \sum_j N_{ij}$; (d) all producer cells maximize profits (9); (e) the government's budget (12) is balanced; and (f) the goods market clears for each producer cell,

$$Q_j = \sum_{j' \in \mathcal{J}} X_{jj'} + x_j + \sum_i c_{ij} + G_j.$$

Calibration. We calibrate the model in exactly the same way as before. We choose $\overline{W}_i = 1$, equal to the wage in the calibration in Section VI.C. We calibrate the disutility shifter φ_i such that labor supply N_i is also exactly equal to the value in Section VI.C. The big difference of this model relative to that in Section VI is that labor supply responds to shocks and policies, whereas in Section VI, labor supply is inelastic.

[A9] Recall that our economy operates a fixed exchange rate with foreign price $P_{\mathcal{R}} = 1$.

Appendix References

Silva, J. S., and S. Tenreyro (2006): "The Log of Gravity," *Review of Economics and Statistics*, 88, 641–658.