Micro- and Macroeconomic Impacts of a Place-Based Industrial Policy

Enghin Atalay Ali Hortaçsu Mustafa Runyun
Chad Syverson Mehmet Fatih Ulu*

March 15, 2025

Abstract

We evaluate a set of place-based subsidies introduced in Turkey in 2012. Using firm-level balance-sheet data along with data on the domestic production network, we first assess the policy's direct and indirect impacts. We identify increased economic activity in industry-province pairs targeted by the subsidies, with positive spillovers to firms' customers and suppliers. Using a dynamic multi-region multi-industry general equilibrium model, we assess the program's aggregate impacts. According to the calibrated model, the subsidy program reduces inequality between the relatively underdeveloped and more prosperous portions of the country. However, trade, migration, and investment spillovers blunt the policy's impact on regional inequality.

JEL Codes: D57, F16, H25, J38, R12

*Atalay: Research Department, Federal Reserve Bank of Philadelphia, atalayecon@gmail.com; Hortaçsu: Department of Economics, University of Chicago, hortacsu@uchicago.edu; Runyun: Department of Economics, Boston College, runyun.mustafa@gmail.com; Syverson: University of Chicago Booth School of Business, chad.syverson@chicagobooth.edu; Ulu: College of Administrative Sciences and Economics, Koç University, mulu@ku.edu.tr. Ulu thanks TÜBİTAK (Türkiye Bilimsel ve Teknolojik Araştırma Kurumu; the Scientific and Technological Research Council of Turkey) for financial support related to this project. We thank various seminar and conference audiences and our two conference discussants: Giacomo Ponzetto and Daisoon Kim. We thank, as well, Mehmet Fatih Kacır, İlker Murat Ar, Elif Tuğçe Çınar, Onur Sarıkaya, and Ramazan Seyfeli, and staff at the Turkish Entrepreneur Information System, part of the Turkish Ministry of Industry and Technology. Nicole Kimmel provided excellent research assistance. The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System. Any errors or omissions are the responsibility of the authors.

1 Introduction

Incomes differ markedly within countries. In the United States, for instance, 2022 income per capita in the richest metro area (Midland, Texas: $143,728) was four times greater than that in the poorest (McAllen, Texas: $33,525; Bureau of Economic Analysis, 2023). In Turkey, the focus of this paper, differences in economic activity are at least as stark.[1] While some of the spatial differences in income per capita reflect variation in workers' human capital, a large portion is due to inequality in economic opportunities. These differences are pervasive, highly persistent, and, when left unchecked, undermine social cohesion (Tabellini, 2010; Algan and Cahuc, 2014).

In response to these types of disparities, governments have implemented a wide range of place-based subsidies. But to what extent do these policies reduce inequality regional inequality? As is well appreciated, place-based subsidies may (by increasing local rents) benefit owners of land and capital (who may or may not reside within the targeted area.) Less well appreciated, since firms' customer and supplier networks extend beyond their localities, and since finding and developing relationships with new trading partners is costly, place-based policies may benefit firms outside of the regions that governments target. Finally, to the extent that workers may migrate in response to the introduction of place-based policies, shifts in labor supply may reduce the policy's impact on regional income inequality.

This paper examines the impact of a prominent place-based policy. In 2012, with Law 2012/3305, the Turkish government introduced a new system of investment and wage subsidies. With levels of generosity varying by province, and with eligibility varying by industry, firms could benefit from a combination of a reduced corporate income tax rate, social security payment assistance, and interest rate subsidies on private loans. We explore three main questions. First, how much did the subsidy system boost economic activity among directly impacted firms? Second, how large were spillovers, through the production network, to the suppliers and customers of firms who were directly impacted, and to what extent do spillovers extend to customers and suppliers beyond the regions targeted by the Turkish government? And third, to what extent did the new subsidies reduce inequality between the relatively poor southeast and the relatively prosperous west of the country?

We address these questions with detailed data on firms' take-up of individual subsidy items; their revenues, investment, employment, and other balance-sheet information; and their customer and supplier relationships. We supplement these data with information on migration flows across regions. Each of these pieces of information is critical. Data on statutory subsidy rates, subsidy take-up, and firm-level measures of economic activity are necessary to evaluate the direct firm-level impact of the new subsidy scheme. Data on buyer-supplier relationships allow us to track indirect spillovers throughout the production network. Data on migration are

[1] In 2022, GDP per capita in Kocaeli, in the northwest of the country, was 5.6 times greater than in Van, a province bordering Iran in the southeast (Turkish Statistical Institute, 2023).

critical towards understanding whether worker flows act as a countervailing force of the new subsidies on regional wage inequality.

We begin our analysis by considering the time paths of revenues, employment, and capital at the industry and province levels, comparing economic activity in province-industry pairs with differential exposure to the subsidies. We first check for pre-trends: We confirm that industry-province pairs eligible for exceptionally generous subsidies after the subsidies were introduced did not systematically grow quickly in the years prior to 2012. We then document that heavily subsidized industry-province showed exceptionally strong growth in capital stocks, employment, and revenues. Next, we exploit our firm-level balance-sheet data, assessing whether subsidized firms directly increased their revenues, employment, and productivity: At the firm-level, we find that a 5 percentage point increase in the investment tax credit subsidy rate corresponds to a 16.2 percent increase in revenues, an 8.7 percent increase in employment, and a 3.3 percent decrease in marginal costs.[2]

We then explore how the spillover effects develop and propagate over the firm network. The indirect effects through the production network are sizable, though meaningfully smaller than the direct effects. A 5 percentage point increase in the fraction of a firm's suppliers and customers who are subsidized corresponds to a 0.7 percent increase in revenues and 0.6 percent increase in employment.

In the final step of our analysis, we explore the aggregate implications of the 2012 subsidy program. To do so, we develop a multi-region multi-industry general equilibrium model, an extension of the framework introduced by Kleinman et al. (2023). We consider two calibrations: one based on our micro regressions and another from matching industry-province-level moments before and after the policy's introduction. The calibrations differ in the overall magnitude of the real wage gains — and the reduction in regional inequality — induced by the subsidy, larger in the moment-matching calibration than in the micro regression calibration. In both calibrations, due to the slow accumulation of capital over time, the policy's impact is larger in the long-run than in the short-run. Also in both calibrations, domestic trade flows, capital income flows, and migration severely mitigate the extent to which the subsidy program reduces inter-province inequality. Absent migration across subsidy regions, the long-run (as of 2040) impact of the subsidy program on regional inequality would be 1.8 times as large; absent both domestic trade flows and domestic migration, the impact would be 2.6 to 2.7 times (depending on whether we are using "micro regression" or "moment matching" calibration) as large; and absent trade flows, domestic migration, and capital income flows, the impact would be either 2.7 to 3.4 times as large. From other perspectives, the subsidy policy appears somewhat more favorable. It likely slowed domestic migration from the poorer eastern parts of the country to the richer (and increasingly congested) İstanbul and its environs. In addition, before the policy's introduction non-employment was considerably higher in the poorer southeastern parts of the country. We

[2]This 5 percentage point difference corresponds, for firms in eligible industries, to the difference in investment tax credits received in regions with the most and least generous subsidies.

find that the policy reduced non-employment, especially in these targeted areas.

Our work contributes to and builds on three related literatures: one which evaluates the direct impact of place-based policies on firms' activity, a second which investigates spillovers within production networks, and a third which examines trade and migration flow responses to broader policy reforms (looking beyond place-based policies). Neumark and Simpson (2015) review the first of these literatures. Among the papers in this review, Bernini and Pellegrini (2011); Givord et al. (2013); Busso et al. (2013); and Criscuolo et al. (2019) assess the impact of place-based subsidies in, respectively, Italy, France, the United States, and the United Kingdom.[3] While the design and implementation of these place-based policies differ — the investment subsidies provided by Law L488 in Italy are determined via a region-specific quota, unlike in other countries; the French subsidies favor firms with fewer than 50 employees, and so on — all four papers find positive employment effects for treated firms. As far as we are aware, we are the first to examine spillovers of place-based policies across the supply chain, the first to use a dynamic general equilibrium model with trade and migration to assess a place-based policy's short-run and long-run general equilibrium spillovers,[4] and the first to examine the direct firm impacts or the general equilibrium impacts of Law 2012/3305 in Turkey.[5]

Second, our work relates to a large literature exploring spillovers within production networks in general, and within Turkish production networks in particular. Barrot and Sauvagnat (2016) and Carvalho et al. (2020), respectively, consider the effect of spillovers between customers and suppliers following from natural disasters in the United States and Japan. Demir et al. (2024a) explore the impact of (foreign) demand shocks to firms' suppliers, customers, and workers, while Demir et al. (2024b) study spillovers of increases in import tariffs within the domestic production network. Our contribution, relative to this second literature, is to investigate the propagation of subsidy-induced shocks among firms within the buyer-supplier network.[6]

[3]More recent work assessing includes Fajgelbaum and Gaubert (2020); Slattery and Zidar (2020); and Gaubert et al. (2021). In a developing economy context, Chaurey (2017), Lu et al. (2019), and Kim et al. (2021) study, respectively, place-based policies in India, China, and South Korea, finding positive impacts of the introduction of place-based subsidies on investment and employment.

[4]Kline and Moretti (2014) examine the long-run impacts of the Tennessee Valley Authority (TVA), a large-scale public infrastructure program introduced in 1933. More recently, Incoronato and Lattanzio (2024) and Choi and Levchenko (2024) consider the long-run impacts of industrial policies introduced in the 1960s and 70s in, respectively, Italy and South Korea. Unlike these papers, we do not have the privilege of a long historical record to judge the success of Turkey's Law 2012/3305. Our contribution is to extend a state-of-the-art dynamic spatial general equilibrium model to (i) estimate long-run impacts and (ii) to understand the relative importance of different spatial spillovers that have been proposed in the literature.

[5]Sungur (2019) describes the 2012 subsidy program, then demonstrates that investment has increased faster in more heavily subsidized regions. However, since investment growth had been faster in heavily subsidized regions, even before the implementation of the 2012 subsidy program, these aggregate trends documented by Sungur (2019) are difficult to parse.

[6]Without looking directly at firm-to-firm links, but seeking to understand spillovers among firms within the same region, Greenstone et al. (2010) assess the impact of the entry of a large subsidized manufacturing plant on existing establishments, finding substantial but heterogeneous TFP gains. Closer to the current paper, Etzel et al. (2021) investigate a place-based policy in Germany, one which aimed to boost manufacturing

Third, we build on a literature seeking to understand the general equilibrium trade, capital investment, and migration responses to policy reforms (or to other shocks). Within this literature, Caliendo et al. (2019) analyze shifts in employment across U.S. states and industries in response to the "China shock" (Autor et al., 2013); Monras (2020) explores U.S. inter-industry, inter-state employment shifts in response to migration induced by the 1995 Mexican peso crisis; Faber and Gaubert (2019) study the trade and migration responses to the rise of the Mexican tourism industry; while Caliendo et al. (2021) examine the impacts of EU enlargement on migration and trade. Kleinman et al. (2023) extend these analyses to incorporate forward-looking capital investment. We combine elements from various extensions of Kleinman et al. (2023)'s model, adding new ingredients, to address a new question—to understand the internal migration flow responses and overall welfare impacts of a prominent place-based policy in a newly industrialized economy.[7]

2 Institutional Background

Enacted on June 19, 2012, the "Decision on State Aid in Investments" (Law 2012/3305) is a set of subsidies introduced by the Turkish government.[8] While the program has multiple stated aims, the one we focus on is its attempt to "reduce regional development disparities."[9] The subsidy program consists of multiple components, with variation in the program design that is both industry and province-specific. The Turkish government partitioned the country into six "subsidy regions," determining the generosity of the individual subsidy items for firms in eligible industries. Figure 1 presents a map of the six regions, with Region 1 receiving the lowest and Region 6 receiving the highest level of support. Region 1 includes the four most populous

investment and employment in the relatively low-income East Germany. Like Greenstone et al. (2010), they find considerable within-region spillovers, but modest spillovers across regions. Finally, in the context of place-based subsidies introduced in Japan in the 1980s and 1990s, LaPoint and Sakabe (2022) examine spillovers *within* firms, from establishments located in areas eligible to receive a subsidy to those located in un-targeted areas.

[7] Kleinman et al. (2023) have a baseline model — with multiple regions and a single industry within each region — with a panoply of extensions. We integrate elements from some of these extensions: exogenous agglomeration effects (as in their Online Supplement S.4.2), multiple industries with input-output linkages (as in Online Supplement S.4.5), investors earning some of their income from capital rented to regions other than where they reside (similar to Online Supplement S.4.8), and non-employment (as in Online Supplement S.4.9). Kleinman et al. (2023) have written out the mathematical solutions for these extensions. But they have not written out the associated code for the first three. Distinct from all of the aforementioned extensions, and motivated by the fact that a key plank of the policy was to subsidize capital investment, we model part of the impact of the subsidy policy as shifts to the returns on capital. Also distinct from any of their extensions, we include land as a factor of production (as in Caliendo et al., 2019).

[8] Even though Law 2012/3305 was introduced in June 2012, subsidies were retroactively applied back to January 2012.

[9] See the *Official Gazette* of the Turkish government:
`https://www.sec.gov/Archives/edgar/data/869687/000119312520247247/d30195dex99d.htm` . Accessed February 24, 2025.

provinces — İstanbul, Ankara, İzmir, and Bursa — while Region 6 is largely within the east and southeast of the country. Second, for each province, the Turkish government designated only certain sets of industries to be eligible for subsidization. These industries are primarily those in the agriculture, mining, manufacturing, and wholesale sectors, with slight variation across provinces in the set of industries that are eligible.[10,11]

Figure 1: Turkish Subsidy Regions
Notes: Source: KPMG (2018).

Several complementary investment incentives were offered to firms in designated industry-province pairs. Qualified projects benefit from:[12,13]

- VAT and customs duties exemptions on machinery and equipment purchased as part of

[10]These industries may have been prioritized as other aims of Law 2012/3305 were to "steer savings to high value-added investments" and to boost a "production and export-oriented growth strategy;" see `https://www.sec.gov/Archives/edgar/data/869687/000119312520247247/d30195dex99d.htm`. Accessed February 24, 2025. In addition to these stated aims, this list of chosen industries align with Liu (2019)'s theoretical predictions. In the presence of market imperfections, Liu (2019) argues that developing economy subsidies should target relatively upstream industries (which coincide with the industries that the Turkish government has targeted).

[11]We list the correspondence between provinces and industries in Appendix B.1. See `https://web.archive.org/web/20210603084940/resmigazete.gov.tr/eskiler/2012/06/20120619-1-2.xls` for the source material for these correspondences . Accessed November 14, 2021.

[12]See `https://www.trade.gov.tr/investment/schemes/regional-investments`. Accessed November 14, 2021.

[13]To qualify, the capital investments must exceed a threshold amount, with the size of the threshold varying by region and industry. For most industries, the minimum investment threshold is 500 thousand TL in Region 6, and up to 4 million TL in Region 1. See `https://trade.gov.tr/data/5b8f8bcd13b8761f041fe88c/9781b45b7769515c32b157910f46cdfd.pdf`. Accessed November 14, 2021. As a result, subsidy take-up will be greater for larger firms. While interesting, we do not consider this source of within industry-by-province heterogeneity in this paper.

the project;

- investment tax credits, ranging from 15 percent in Region 1 to 50 percent in Region 6;[14,15]
- for additional employment created by the investment project, employers receive support for their mandatory contribution to employees' social security payments, ranging from two years in Region 1 to ten years in Region 6.;
- for additional employment created by the investment project, support for the employee's contribution of their own social security payments, in Region 6 only; and
- support on interest rates (for loans obtained from banks or other private financial institutions to finance project-related investments), ranging from no support in Regions 1 and 2 to either (i) 7 percentage points for Lira-denominated loans or (ii) 2 percentage points for foreign-currency-denominated loans in Region 6.

To qualify, eligible firms must apply to the Turkish Ministry of Industry and Technology. Firms must demonstrate that their investment project satisfies the rules within Law 2012/3305, applying for an "investment incentive certificate." This certificate describes the subsidy items from which the firm can benefit. Certificates are "open" while the project has been approved but before the investments have been made, and "closed" once the proposed project has been completed. While the certificate is open, firms benefit from VAT and Customs Tax exemptions and interest rate support. Firms receive investment tax credits and social security support only after the certificate is closed.[16]

While there are multiple types of subsidies that firms may receive, in practice these subsidies are bundled with one another. Ideally, we would have a firm-specific index to fully characterize firms' exposure to subsidization. Not quite able to do that, we apply the investment tax credit rate — the percentage point credit in corporate taxes linked to the firm's investment — as

[14] These investment tax credits are deducted from firms' corporate tax obligations. These tax credits are deducted over a number of years, with the speed at which firms receive subsidies also varying by region.

[15] In addition to the regional subsidy program introduced in 2012, Turkey has 258 (as of 2021) "Organized Industrial Zones" (OIZs), special economic zones of much smaller geographies. See `https://www.invest.gov.tr/en/investmentguide/pages/investment-zones.aspx` (accessed November 14, 2021). As of 2021, approximately 2 million individuals worked in an OIZ. The first OIZ was introduced in 1960, with the number of OIZs increasing steadily over the last six decades (Cansız, 2010). While the OIZ program precedes and is largely independent of the region-based subsidies introduced in 2012, the subsidies associated with Law 2012/3305 are slightly more generous in OIZs. The generosity levels listed in this section apply to areas outside OIZs. Appendix B.2 lists the statutory subsidy rates inside and outside OIZs. In our firm-level and industry-level analysis, we use the statutory generosity rates applicable outside of OIZs.

[16] In Appendix B.3, we estimate government expenditures on investment tax credits and rebates for employers' and employees' mandatory social security contributions, the two most prominent elements of the subsidy program. We estimate that expenditures on these two subsidy items were 10.4 billion TL in 2019 (in 2010 prices), roughly 0.57 percent of GDP in that year. (TürkStat, the Turkish Statistical Institute, reports that nominal GDP was 4.31 trillion TL in 2019, equivalent to 1.84 trillion TL in 2010 prices.)

Table 1: Pre-policy Differences in Subsidy Regions

	Region						
	1	2	3	4	5	6	Nationwide
Population (Millions)	30.4	11.2	9.8	7.9	6.6	8.8	74.7
Net Migration Rate (%)	0.86	0.07	-0.33	-0.60	-1.09	-1.24	—
GDP Per Capita (, 000 TL)	27.36	16.54	14.95	13.38	11.23	8.30	18.95
GDP Per Capita Growth Rate (%)	1.5	2.0	2.2	3.4	3.9	3.7	2.3

Notes: The data for this table come from Turkish Statistical Institute (2022a,b, 2023). The first three rows list values as of 2011. The final row lists average (annual) growth rates between 2006 and 2011. All values are reported as 2010 Turkish Liras (TL). As of January 2010, the TL to US dollar exchange rate was 1.50 to 1.

a suitable albeit imperfect measure of the extent to which firms' inputs are subsidized. In sensitivity analyses, we consider other measures — the number of years of support for employers' mandatory contributions of social security payments, whether the firm has a "closed" subsidy certificate (irrespective of the level of generosity), or total subsidy expenditures received by the firm (relative to the value of the firm's plant, property, and equipment capital in 2011). We find that the relationships between firms' economic activity and the subsidies they receive are similar across these measures.

In Table 1, we explore differences in pre-plan economic conditions across the six subsidy regions. Consistent with the 2012 subsidy program's aims, the more highly subsidized regions had lower GDP per capita in 2011, with Region 6 having less than one-third of Region 1's GDP per capita. In the years (and decades) prior to the subsidy program, migration within Turkey occurred from the relatively poor Central, Eastern, and Southeastern Anatolia (in Regions 3, 4, 5, and 6) to the large urban centers: İstanbul, İzmir, and Ankara (in Region 1.) Finally, at least in the half-decade prior to the introduction of the subsidy program, GDP per capita growth rates were larger in Regions 5 and 6 relative to Regions 1 and 2. These pre-treatment differences in levels and trends threaten the identification of subsidy program's impact, as it is *a priori* plausible that the government's subsidy program was targeted towards province-industry pairs that were growing exceptionally quickly in the pre-policy period and would have continued to grow faster than average absent the subsidy program. We discuss the issue of pre-trends in Section 4, after introducing our main datasets in the following section.

3 Data Sources and Summary Statistics

We merge four firm- and employee-level datasets from the Entrepreneur Information System (EIS) of the Turkish Ministry of Industry and Technology. (In addition, below, when discussing the aggregate implications of the subsidy program in Section 5, we apply information from the World Input-Output Database, from Timmer et al., 2015, 2016.) Our firm-level datasets include: (i) firm balance-sheet data, spanning 2006 to 2019; (ii) data on subsidy take-up rates,

Table 2: Descriptive Statistics: Firm-Level Balance-Sheet Variables

		N	Mean	SD	Percentile 25	50	75	95	99
(1)	Employment	1,039,766	87.13	347.74	24.00	34.50	62.50	268.50	926.50
(2)	Wage Bill (Millions)	1,039,766	1.4	9.1	0.2	0.4	0.8	4.4	17.9
(3)	Real Sales (Millions)	1,039,760	26.0	327.2	1.3	3.7	11.0	63.3	309.4
(4)	PPE Capital (Millions)	1,039,766	10.1	149.9	0.2	0.8	2.9	22.1	132.1
(5)	$\Delta \log(\text{PPE})$	902,639	0.12	0.78	-0.15	-0.02	0.27	1.33	2.98

Notes: All values are reported as 2010 Turkish Liras (TL). The sample includes firms with at least 20 employees.

from 2012 to 2019; (iii) the firm-to-firm production network, from 2006 to 2019; and (iv) linked employer-employee data, from 2012 to 2019. Our main analysis is restricted to firms with at least 20 employees since many balance-sheet variables are recorded only for these firms. In Appendices A.1, we describe our dataset in greater detail. We assess how closely aggregates based on our EIS data align with those in public-use aggregate datasets in Appendix A.2.

While incredibly rich and detailed, there are two important limitations of these micro data. First, the EIS data cover only formal economy firms and employees — workers registered in the social security system — and additionally exclude most Agricultural, Financial, and Public Sector firms. As of 2017, about 34 percent of workers were informal (though, since formal-sector workers earn considerably more than their counterparts in the informal sector, informal workers comprise a substantially smaller share of the aggregate wage bill); see Figures 21 and 51 of Acar and Carpio (2019). Compounding this limitation, the share of formal-sector workers varies considerably by industry and region, with a greater share of informal workers in agriculture and in the southeast of the country; see Figures 24 and 25 of Acar and Carpio (2019). Thus, our data miss a substantial fraction of economic activity, with the under-representation systematically varying with firms' subsidy eligibility. Second, with the exception of the number of workers, the balance-sheet data are at the firm level, not the establishment level. (For subsidized firms, we *do* observe the location and industry of the establishment through which the firm applied for the subsidy.) So, in interpreting firm-level relationships between subsidization and firm-level activity, we have to be mindful that some firms may operate multiple establishments with different levels of exposure to the subsidy program.

Both limitations can be overcome, albeit imperfectly. Regarding the first limitation, in Appendix A.3 we construct estimates of informality by province and industry. We apply these estimates of informality when computing aggregate trade or migration flows across industry-subsidy region pairs — in Figures 2 and 3 in this section and in the calibration of our Section 5 model — from the micro data. Regarding the second limitation, we demonstrate that our evaluation of the subsidy's impact on firm activity is robust to excluding firms with establishments in multiple industry-province pairs.

Table 2 presents summary statistics related to the firm balance-sheet data. Among the

Table 3: Descriptive Statistics: Subsidy Take-up

		Mean	SD	Percentile 90	Percentile 95	Percentile 99
(1)	Firms with an Open or a Closed Certificate	0.052	0.222	0	1	1
(2)	Firms with a Closed Certificate	0.025	0.155	0	0	1
(3)	Eligible to Receive Subsidy	0.144	0.351	1	1	1
(4)	Investment Tax Credit Rate	0.017	0.078	0	0	0.4
(5)	Investment Tax Credit Rate, with Closed Certificate	0.008	0.056	0	0	0.4
(6)	Investment Tax Credit: Statutory	0.035	0.090	0.15	0.25	0.4
(7)	Social Security Employer Premium—Years of Support Received	0.301	1.468	0	0	7
(8)	Social Security Employer Premium—Years of Support Received, with Closed Certificate	0.143	1.042	0	0	7
(9)	Social Security Employer Premium—Years of Support: Statutory	0.599	1.649	2	5	7

Notes: The sample includes firms with at least 20 employees. For non-subsidized firms, the investment tax credit rate (row 4) and social security employer premium (row 7) are set to 0. For firms without a closed subsidy certificate (rows 5 and 8), the corresponding subsidy measures are set to 0. Our measures of statutory subsidy rates refer to those outside of Organized Industrial Zones (see footnote 15). N=1,039,766.

firms in our sample, the median firm-year observation had 35 employees, with revenues of 3.7 million Turkish Lira (equivalent to approximately 2.4 million 2010 US dollars), and 800 thousand Turkish Lira in plant, property, and equipment (henceforth "PPE") capital.

Second, we measure subsidy take-up rates in Table 3 using three metrics: the fraction of subsidized firms (rows 1 through 3), the average investment tax credit ratio (rows 4 through 6), and the number of years for which the firm receives social security support (rows 7 through 9). The third row describes observations of those who were statutorily eligible to receive a subsidy: These are observations after 2012 where the firm belonged to a subsidized industry-province pair. According to this row, 14.4 percent of the observations could (feasibly, according to Law 2012/3305) receive a subsidy. Among the 14.4 percent, 5.2 percent of observations correspond to a firm which had successfully applied for the subsidy (row 1). An even smaller fraction, 2.5 percent of the sample, has a closed subsidy certificate (row 2). Rows 4 through 6 consider investment tax credit rates. The statutory investment tax credit rate ranges up to 50 percent for firms in the sixth subsidy region (row 6). However, both because many firms were ineligible to receive a subsidy and because investment tax credits were less generous in the lowered-numbered regions, the average investment tax credit rate that firms were eligible to receive is much lower: 3.5 percent. Again, since not all eligible firms received a subsidy, the average investment tax credit received was even lower, at 1.7 percent. Similarly, the number of years firms received employment subsidies is highly skewed (rows 7-9).

Our third database measures information on firms' domestic customers and suppliers. Ac-

Table 4: Descriptive Statistics: Firm-to-Firm Production Network

		Mean	SD	Percentile 25	50	75	90	95	99
(1)	Number of Customers	19.8	69.9	1	6	18	45	76	202
(2)	Number of Suppliers	19.8	39.4	3	9	22	45	69	166
(3)	Number of Customers in the Same Subsidy Region	13.8	53.5	1	4	12	31	54	149
(4)	Number of Suppliers in the Same Subsidy Region	13.8	29.9	2	6	14	32	52	128
(5)	Number of Customers in the Same Province	9.7	36.6	0	2	8	22	39	105
(6)	Number of Suppliers in the Same Province	9.7	20.5	1	4	10	23	36	89

Notes: The sample includes firms with at least 20 employees. N=924,368.

cording to Table 4, the median firm in our dataset had 9 suppliers and 6 customers. Consistent with other studies of production networks (Bernard et al., 2019; Carvalho et al., 2020), the degree distribution is highly skewed, somewhat more so for the distribution of the number of customers than for the distribution of the number of suppliers. A small number of firms have a disproportionate number of suppliers and (in particular) customers. There are a substantial number of inter-firm relationships that traverse different subsidy regions. Approximately 30 percent ($\approx 6.0/19.8$) of relationships occur across subsidy regions.

Central to our analysis of the aggregate effects of the subsidy program are measures of linkages across the six subsidy regions. In the remainder of this section, we depict these linkages. In Figure 2, we report the trade flows across region pairs for each industry in our sample. (This figure applies combinations of 2-digit NACE industries, in accordance with the calibration of our Section 5 model.) The shading represents the share of the destination region's purchases that are sourced from each of the six regions. In the aggregate, 58 percent of shipment value occurs within subsidy regions. However, downstream firms' reliance on inputs sourced from other subsidy regions varies considerably: For downstream firms located in Region 1, 76 percent of shipment value is sourced from suppliers located in Region 1. Elsewhere, 38 percent of shipment value is sourced from suppliers within the same subsidy region. Taken together, a substantial fraction of each region's purchases are sourced either within-region or from provinces in (the most developed) Region 1.

Figure 3 depicts labor flows across pairs of subsidy region-industry pairs. The shading within each cell corresponds to the share of individuals in a particular source region-industry pair who end up in each destination region-industry pair. The dark diagonal within this s, including a continued increase in subsidization take-up,figure indicates that workers tend to migrate across regions–industry pairs infrequently. Indeed, 19.4 percent of workers transition to a different destination industry region-pair, with 1.6 percent of workers switching regions from one year to the next.[17]

[17]The former figure excludes individuals who are transitioning into or out of non-employment. The latter figure is similar to the inter-state migration rate (1.5 percent) observed in the US (Kaplan and Schulhofer-

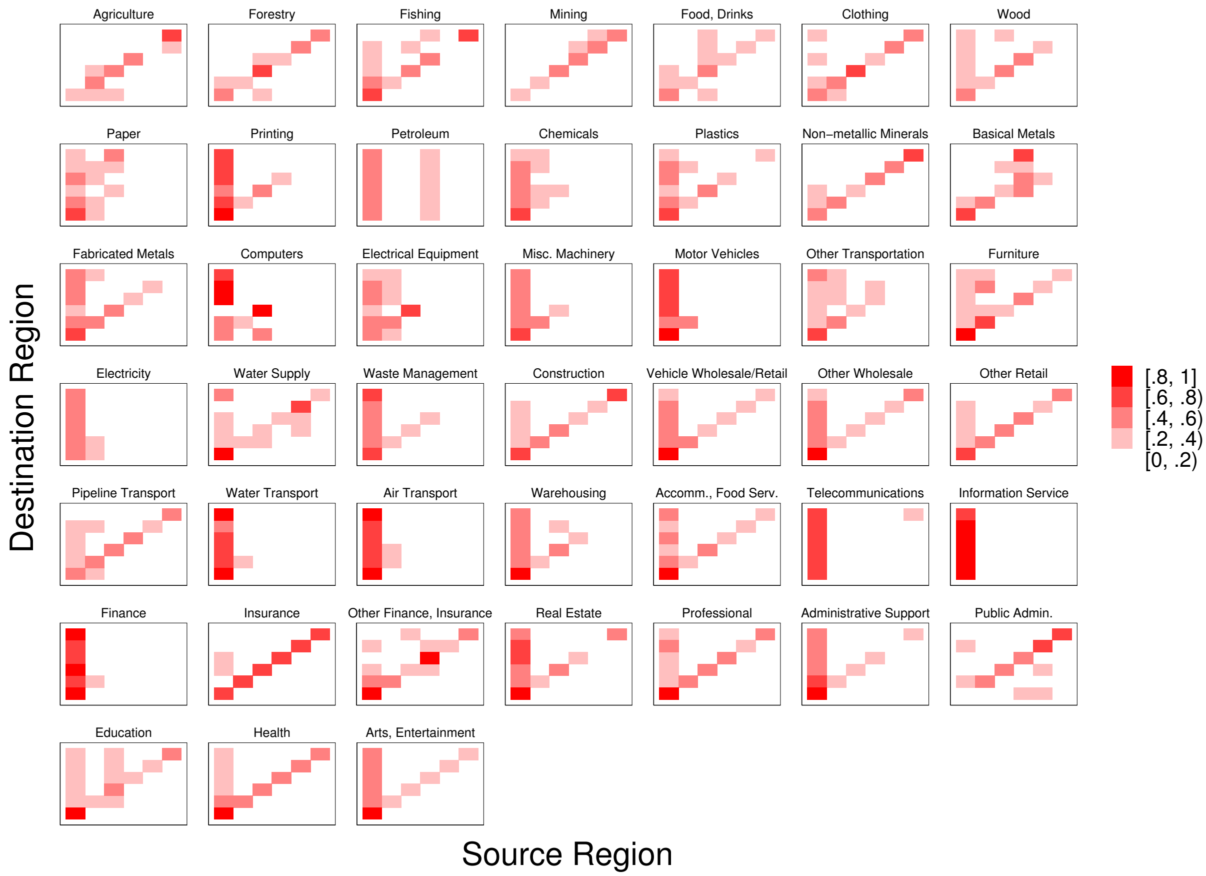

Figure 2: Intermediate Input Flows
Notes: Each panel displays, for a separate commodity, the share of the destination region purchases that come from each source region. Regions are sorted from left to right and bottom to top. This figure uses data from 2012. Within each panel, there are six rows and six columns. Region 1 is in the leftmost column and bottom-most row in each figure; Region 6 is the rightmost column and topmost row in each figure.

To summarize, these descriptive statistics show that subsidization rates are skewed — concentrated in certain industries and regions — with significant trade and migration linkages across the six subsidy regions..

4 Direct and Indirect Microeconomic Effects

In this section, we examine the microeconomic impacts of the 2012 subsidy program. In Section 4.1, we describe our empirical setup. We present the relationship between subsidization and economic activity: at the industry-province level in Section 4.2 and at the firm level in Section 4.3. Finally, in Section 4.4 we assess spillovers from subsidized firms to their customers, to their

Wohl, 2012).

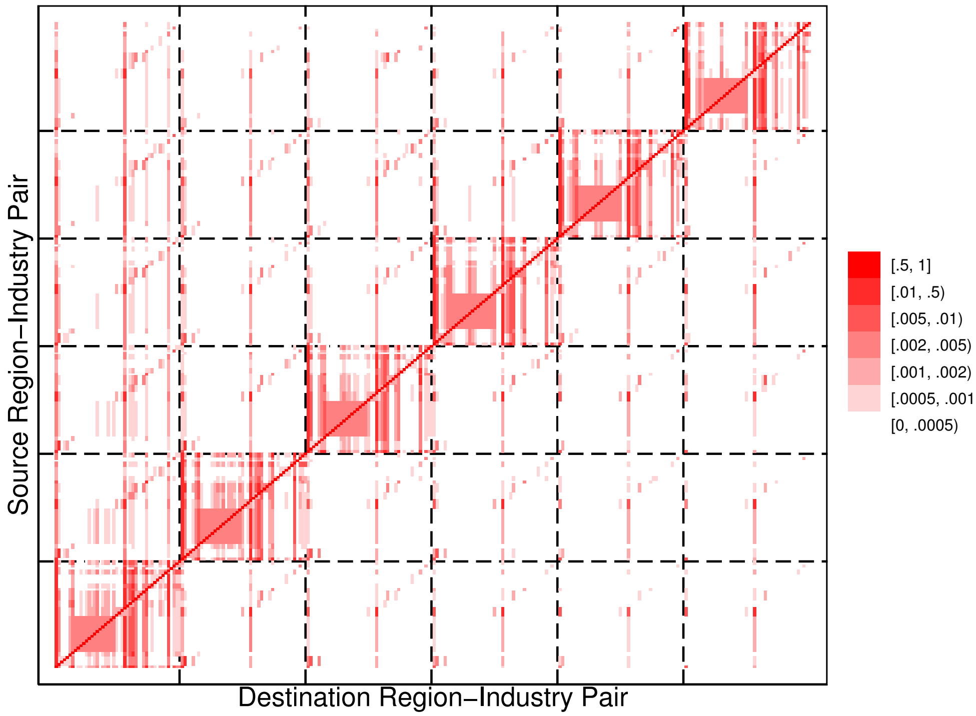

Figure 3: Labor flows
Notes: This figure presents flows of workers across region-industry pairs, between 2012 and 2013. Region-industry pairs are sorted by regions first, then by industries, with Region 1 and the first industry ("Non-Employment") listed in the leftmost column (and bottom row) and Region 6 and the final industry ("Education") listed in the rightmost column (and top row). Dashed lines demarcate each of the six subsidy regions. The shading represents the share of 2012 individuals for a given source region-industry pair who, in 2013, move to the destination region-industry pair.

suppliers, or to workers in their local labor market.

4.1 Set-up

Our main empirical setup to detect direct effects is a difference-in-difference regression:

$$y_{pnt} \quad = \quad \beta_{pn} + \beta_{nt} + \beta_1 S_{pnt} + \varepsilon_{pnt} \ . \tag{1}$$

Here, y_{pnt} is some measure of economic activity in a given province-(4-digit) industry pair p-n in year t. We will compare this measure of economic activity to the level of subsidization, S_{pnt}, at that given point in time. We use industry-province and industry-year fixed effects to control for the overall scale of economic activity in the province-industry pair or for macroeconomic shocks that differentially impact different types of industries.

Interpreting β_1 as a causal estimator of the subsidy program's effect on economic activity presents three challenges. First, it is possible that the industry-province pairs most exposed to the subsidy program were growing relatively quickly (or relatively slowly) in the years prior to the introduction of the subsidies. (Our Table 1 finding that heavily subsidized regions, Regions 5 and 6, had relatively fast GDP per capita growth in the five years prior to introduction of Law 2012/3305 lends credence to this concern.) A second challenge is that not every firm eligible to receive subsidies actually applied. To the extent — when comparing firms (or industry-province pairs) within the same industry and subsidy region — that firms more likely to select into the program would have grown exceptionally slowly absent the new policy, OLS estimates of Equation 1 may understate the policy's impact. Third, and related, as we have discussed in Section 2, whatever measure we apply for S_{pnt} will imperfectly capture industry-province pairs' exposure to subsidization.

In Section 4.2, we discuss our instrumental variables strategy to confront the second and third of these three challenges. Regarding the first, we explore the issue of pre-trends with an amended version of Equation 1, described by:

$$y_{pnt} - y_{pn,2011} = \beta_{nt} + \beta_{pt} + \beta_{1t}\widetilde{S}_{pn} + \varepsilon_{pnt} \ . \tag{2}$$

The aim of this regression is to compare industry-province pairs' pre-policy growth rates to their post-2012 subsidization levels. Equation 2 differs from Equation 1 in four ways. First, given that the aim of Equation 2 is to compare pre-policy growth rates with post-2012 subsidization — and not to compare contemporaneous subsidization and economic activity as in Equation 1 — we replace S_{pnt} with $\widetilde{S}_{pn}$: the statutory investment tax credit rate available post 2012 in province p and industry n. Second, the coefficients that we estimate β_{1t} are allowed to vary by year; this permits the construction of "event-study" plots. Third, given that $\widetilde{S}_{pn}$ is a time-invariant measure, Equation 2 omits the industry-province fixed effects that were present in Equation 1. Fourth, since we have modified our coefficient estimate β_{1t} to vary by year, we include province-year fixed effects as well.

Figure 4 presents our estimates of β_{1t} using three alternate activity measures: the logarithm of real sales ("revenues"), the logarithm of the real value of the capital stock ("plant, property, and equipment capital"), and the logarithm of the number of employed workers in the industry-province pair. In the left column, we weight province-industry pairs according to the average firm count within the sample period; in the right column of panels, province-industry pairs are weighted equally. In five of the six specifications, we cannot reject the null hypothesis that $\beta_{1t} = 0$ for each year between 2006 and 2010. We can reject this null hypothesis in one of the six specifications — with employment as the measure of economic activity and weighting by firm counts. Here, the most heavily subsidized province-industry pairs had exceptionally quick employment growth between 2008 and 2009 and exceptionally slow employment growth between 2009 and 2011. Averaging over the two sub-periods, there is no significant difference in employment growth rates across industry-province pairs of different exposures to the subsidy

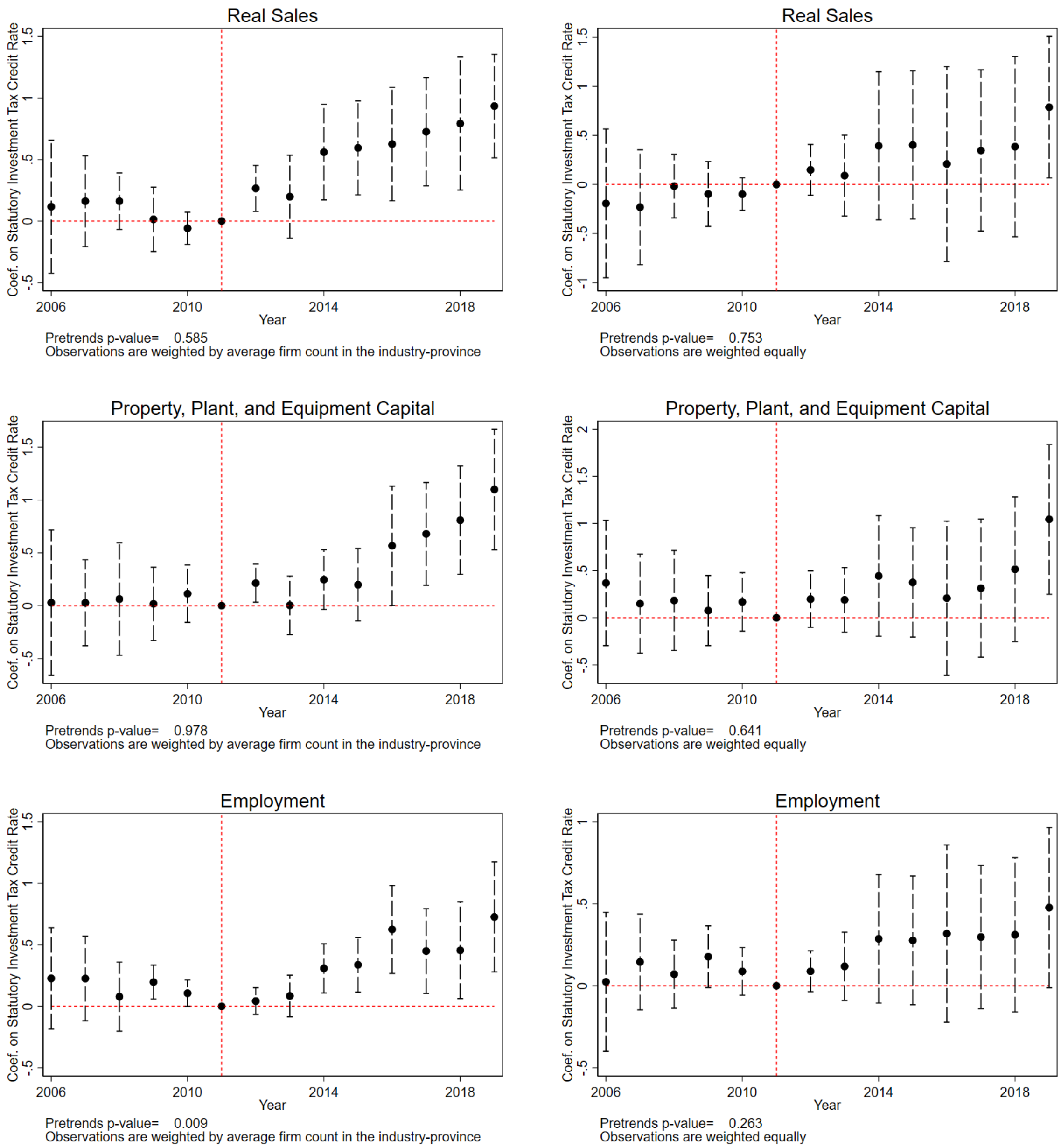

Figure 4: Examination of pre-trends
Notes: Within each panel, we plot estimates of β_{1t}. The dashed lines give 2-standard-error confidence intervals, with standard errors clustered by province-year. The sample includes all industry-province pairs for which there are at least 20 firms within the cell every year within the sample period. The left column of panels weights cells according to average firm-count within the sample period; the right column of panels weights province-industry pairs equally.

program. In all six specifications — with the possible exception of the unweighted specification with employment as the measure of activity — economic activity is significantly higher at the end of our sample (relative to 2011) in province-industry pairs eligible for more generous subsidies.

4.2 Industry-Level Comparisons

Having examined the issue of pre-trends, we return to our baseline specification (Equation 1) and compare contemporaneous measures of economic activity to measures of subsidization.

In columns (1) though (3) of Table 5, we present OLS estimates of the relationship between revenues and subsidization. We consider two measures of subsidization: the average investment tax credit rate received by firms in province p and industry n (columns 1 and 2), as well as the fraction of firms with a closed subsidy certificate (column 3). In all three specifications, we find that subsidization significantly increases industry-province revenues. A 5 percentage point increase in the average investment tax credit rate — approximately equal to the end-of-sample difference in average investment tax credit rates between Region 6 and Region 1 — corresponds to a 9.3 percent ($\approx 1.855 \cdot 0.05$) increase in industry-province level revenues (column 3). Columns 4 through 6 consider the relationship between subsidization and its employment, while columns 7 through 9 present the estimated relationship between subsidization and plant, property, and equipment capital. Here, we see similar relationships when industry$\times$ year fixed effects are included and an insignificant relationships without them.

Not all firms that are eligible for a subsidy actually apply: There is substantial heterogeneity in subsidy take-up rates both among firms within the same industry-province pair and across industry-province pairs with identical levels of statutory eligibility and generosity.[18] To the extent that firms differ in their propensity to seek and successfully receive a subsidy certificate, and that these differences are correlated with future economic success, our OLS estimates may present a biased estimate of the effect of the subsidy program on economic growth. Further, our explanatory variable measures exposure to subsidization with some error. For these two reasons, we instrument firm (or industry-province) subsidy take-up with measures of subsidy eligibility and generosity. For regressions with the investment tax credit rates received by firms, we instrument by the statutory investment tax credit rate available for firms in the province-industry. For regressions with the share of firms who have received the subsidy as our measure of S_{pnt}, we choose the dichotomous measure of whether the province-industry pair was eligible to receive subsidies as our instrument.

Columns (10) though (18) of Table 5 present our IV estimates. In general, these estimates are

[18]To give one example of the incomplete and heterogeneous subsidy take-up rates, consider Diyarbakır and Batman — two provinces in the sixth subsidy region. These two provinces had, respectively, 22 percent and 40 percent of their rubber and plastics manufacturing firms with a closed subsidy certificate by the end of the sample.

Table 5: Industry-Province Level Observations

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable		Revenues			Employment		Property, Plant, and Equipment Capital		
Investment Tax Credit Rate	0.981**	1.855***		0.033	1.649***		-0.153	1.903***	
	(0.494)	(0.514)		(0.439)	(0.533)		(0.551)	(0.546)	
Closed Certificate			0.645***			0.555***			0.689***
			(0.166)			(0.194)			(0.171)
N	238,206	237,747	237,747	236,593	236,593	236,148	237,888	237,422	237,422
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.949	0.976	0.976	0.959	0.985	0.985	0.942	0.971	0.970
Panel B: IV Estimates	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Dependent Variable		Revenues			Employment		Property, Plant, and Equipment Capital		
Investment Tax Credit Rate	2.112*	6.335***		-1.092	4.019**		-0.617	6.333***	
	(1.275)	(2.081)		(0.820)	(1.572)		(1.012)	(2.282)	
Closed Certificate			0.884			1.504			0.352
			(0.970)			(1.064)			(1.279)
N	238,206	237,747	211,457	236,593	236,148	210,335	237,888	237,422	211,239
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
	First Stage								
Statutory Investment Tax Credit Rate	0.211***	0.161***		0.211***	0.161***		0.211***	0.161***	
	(0.057)	(0.038)		(0.057)	(0.038)		(0.057)	(0.038)	
Eligible for Subsidy?			0.052***			0.052***			0.052***
			(0.021)			(0.021)			(0.021)

Notes: An observation is a year×4-digit NACE industry×province combination. Province-industry pairs are weighted by the number of firms in the sample. All specifications additionally include province-industry fixed effects. The "Closed Certificate" refers to the fraction of firms within the industry-province pair with a "closed" subsidy certificate. The Investment Tax Credit Rate is the average investment tax credit rate received in the province×NACE pair in a year. Standard errors are clustered at the province level.

larger and less precisely estimated. Among the explanations for these larger coefficient estimates, one possibility is that the industry-province pairs which had exceptionally high subsidy take-up rates — relative to others with similar levels of eligibility and generosity — had relatively low growth rates. Alternatively, the investment tax credit rates received could be an imperfect measure of exposure to the subsidy policy, with such measurement error leading to attenuation of the true effect of subsidization on industry activity.[19,20]

So far, we have demonstrated that the 2012 policy led to increased economic activity in the most heavily subsidized industry-province pairs. These industry-level relationships reflect the direct firm-level impact of the subsidies along with spillovers that exist among firms in the same province and spillovers among firms across provinces. In Sections 4.3 and 4.4, we use firm-level balance-sheet and production data to unpack the industry-level impacts uncovered in this section.

4.3 Direct Effects on Subsidized Firms

In this section, we examine the direct effect of the subsidy scheme on firms' revenues, employment, and productivity.

We consider regressions of the form:

$$y_{ft} \quad = \quad \beta_f + \beta_{nt} + \beta_1 S_{ft} + \varepsilon_{ft} \ . \tag{3}$$

Here, y_{ft} is a measure of firm-level activity in year t. We regress this variable against a measure of firm subsidization in year t (S_{ft}), industry-year fixed effects (β_{nt}), and firm fixed effects β_f. In certain specifications, we replace industry-year fixed effects with year fixed effects.[21]

---

[19] In their analysis of the UK Regional Selective Assistant Program's effect on manufacturing employment, Criscuolo et al. (2019) report similar discrepancies between OLS and IV regression results, with IV estimates exceeding OLS estimates by a factor of 7; see their table 4. However, there are at least two relevant differences between the approaches in our papers. In Criscuolo et al. (2019), subsidization varies according to geography, not geography-by-industry as in our paper. Further, the instrument in Criscuolo et al. (2019) exploits plausibly exogenous changes in subsidy rules as an instrument for regions' eligibility for subsidization. For these reasons, our explanations for the differences between OLS and IV estimates will differ from those in Criscuolo et al. (2019).

[20] In Appendix D.1, we examine the sensitivity of our results to how observations are weighted, to controlling for Syrian-refugee population share (at the province-by-year level), and to including province-by-year fixed effects. Weighting observations equally leads, for the most part, to coefficients that are at least as large as in Table 5; controlling for the Syrian-refugee population share has little effect; while the inclusion of province-by-year fixed effects yields somewhat smaller coefficient estimates. Re-estimating Equation 1 with firm counts as the dependent variable, we find that a percentage point increase in the investment tax credit rate leads to a 11 percent increase in the number of firms (column 11 of Table 26).

[21] In Appendix D.2, we re-estimate Equation 3 with two additional variables: the firm's wage-bill and the wage-bill per employee. Expenditures on labor are increasing in subsidization levels. The ambiguous results for average wages per employee are consistent with our findings in Section 5. We also demonstrate that our main conclusions are unchanged with two alternate measure of subsidization for S_{ft}: (i) the number of years for which the firm is relieved from making social security contributions and (ii) the Lira value of subsidies

Table 6: The Impact of the Subsidy Program on Firm Revenues and Employment

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable		Revenues			Employment	
Investment Tax Credit	0.879***	0.807***		1.061***	1.005***	
Rate	(0.072)	(0.065)		(0.088)	(0.080)	
Closed Certificate			0.337***			0.448***
			(0.030)			(0.032)
N	919,931	919,931	901,332	924,368	924,368	905,146
Year FEs	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes
R^2	0.832	0.836	0.839	0.850	0.855	0.858
Panel B: IV Estimates	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Variable		Revenues			Employment	
Investment Tax Credit	2.687***	3.254***		1.561***	1.746***	
Rate	(0.487)	(0.604)		(0.427)	(0.587)	
Closed Certificate			2.989***			2.104***
			(1.755)			(0.879)
N	881,484	881,088	862,408	885,997	885,617	866,304
Year FEs	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes
			First Stage			
Statutory Investment	0.140***	0.132***		0.142***	0.135***	
Tax Credit Rate	(0.010)	(0.019)		(0.010)	(0.019)	
Eligible for Subsidy?			0.025*			0.026*
			(0.015)			(0.015)

Notes: An observation is a firm×year pair. The dependent variables include log(Revenues) or log(employment). All regressions include firm fixed effects. Standard errors are clustered at the province level.

Since we employ firm fixed effects, and since firms' eligibility experiences a one-time shift in 2012, our sample includes only firms who were present both before and after 2012. As with our industry-level regressions, depending on the specification, we instrument firms' received subsidies with variables measuring (i) the share of firms eligible to receive the subsidy or (ii) the statutory subsidy rates firms are eligible to receive.

Columns (1) through (3) and (7) through (9) of Table 6 present the relationship between subsidization and firm revenues. Overall, more generous subsidization leads to greater revenues. Consistent with our industry level-regressions, comparisons of columns (1) through (3) to columns (7) through (9) indicate that IV specifications lead to a stronger estimated relationship between subsidies and revenues.[22] The results from our preferred specification (column 8)

received by the firm (normalized to the firm's pre-policy total assets).

[22]For firms that operate in multiple industry-province pairs, we apply the following procedure to define the instrument. For firms which receive a subsidy, we define the instrument based on the statutory rate in the industry-province pair of the firm's application. For firms which do not receive a subsidy, we define the statutory rate in the industry-province pair of the firm's headquarters. In Appendix D.2, we demonstrate

Table 7: The Impact of the Subsidy Program on Firm Capital Stock and TFP

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Plant, Property, and Equipment Capital			TFP		
Investment Tax Credit Rate	1.962*** (0.120)	2.004*** (0.107)		-0.022 (0.024)	-0.045** (0.022)	
Closed Certificate			0.724*** (0.060)			-0.019 (0.013)
N	898,280	898,280	879,441	860,210	860,210	842,918
Year FEs	Yes	No	No	Yes	No	No
Year× Industry FEs	No	Yes	Yes	No	Yes	Yes
R^2	0.881	0.885	0.886	0.618	0.631	0.635
Panel B: IV Estimates	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Variable	Plant, Property, and Equipment Capital			TFP		
Investment Tax Credit Rate	0.324 (1.244)	4.627*** (0.670)		0.979*** (0.170)	0.657*** (0.235)	
Closed Certificate			3.762** (1.600)			0.254 (0.303)
N	863,069,	862,702	843,780	824,585	824,199	806,806
Year FEs	Yes	No	No	Yes	No	No
Year× Industry FEs	No	Yes	Yes	No	Yes	Yes
	First Stage					
Statutory Investment Tax Credit Rate	0.143*** (0.010)	0.135*** (0.019)		0.142*** (0.010)	0.135*** (0.019)	
Eligible for Subsidy?			0.026* (0.016)			0.026* (0.016)

Notes: An observation is a firm×year pair. The dependent variables include log(PPE) or log(TFP), the latter which is observed is estimated using Ackerberg et al. (2015). All regressions include firm fixed effects. Standard errors are clustered at the province level.

indicate that a 5 percentage point increase in the investment tax credit rate — again, approximately equal to the difference, in 2019, in average subsidy levels between Region 6 and Region 1 — corresponds to a 16.2 log point ($\approx 3.254 \cdot 0.05$) increase in revenues.

The remaining columns of Table 6 present corresponding results for employment. Here, too, subsidies lead to increased economic activity, both in the OLS and IV estimations. According to column (11) of this table, a 5 percentage point increase in investment tax credits received leads to a 8.7 log point increase in firm employment.

In Table 6, we turn to the impact of the subsidy policy on firms' capital stocks and productivity levels. Columns (1) through (3) and (7) through (9) indicate that the subsidy policy increased firms' plant, property, and capital equipment. Here, the IV estimates are somewhat sensitive to the set of fixed effects included in the specification. A 5 percentage point increase in

that our firm-level regressions are similar for the subsample of firms who have all of their establishments in a single industry-province pair.

investment tax credits received leads to either a (statistically insignificant) 1.6 log point increase in the capital stock (column 7) or a 23.1 log point increase (column 8).

Finally, columns (4) through (6) and (10) through (12) of Table 7 record the effect of subsidies on firms' total factor productivity.[23] According to our IV specifications, a 5 percentage point increase in investment tax credit ratios leads to a 3.3 log point increase in TFP (column 11 of Table 7). There are a number of possible mechanisms through which the subsidies may increase firm-level TFP. First, subsidization entails a direct reduction in the effective rental price of capital and wage rate that subsidized firms pay. Thus, the subsidy program led to a reduction in firms' marginal cost of production. Since our measure of TFP is a residual of firms' revenues and their unit input costs, the subsidy program may have led to an increase in measured productivity (revenue productivity, "TFPR," in the nomenclature of Foster et al., 2008) even without altering their true efficiency in measuring inputs into outputs.[24] A second possibility, (un-modeled) frictions — to capital or labor markets — have been leading to inefficient scales of production, especially in the southeast of the country. To the extent that the subsidy program relaxed credit constraints, they may have increased firm efficiency. While understanding the precise mechanism through which the subsidies increase firm productivity is necessary to address many interesting economic questions, it is less salient for the purposes of evaluating the impact of the subsidy program on regional wage inequality.

4.4 Indirect Effects via the Production Network and Local Labor Markets

In this section, we examine spillovers in the effects of the subsidy program along input-output relationships and within firms' local labor markets. There are two purposes of this section. First, we are inherently interested in documenting how the subsidies spill over to the customers or suppliers of subsidized firms. Second, in the calibration of our general equilibrium model in the following section, a key input will be the impact of subsidization on productivity. To the extent that (i) firms' own subsidization status is correlated with their suppliers' and customers' subsidization, and that (ii) counterparties' subsidization leads to higher TFP, our Table 7 estimates from the previous section would suffer from omitted variable bias. For a similar reason, we include an additional control for the wages in the firms' local labor market. The average wage rate paid by firms in a given industry-province pair may respond to the share of firms receiving a subsidy, and may affect individual firms' total factor productivity.

[23]We estimate TFP for each 2-digit NACE industry, using the estimator developed by Ackerberg et al. (2015). Appendix C describes our specification in greater detail, then presents the estimated production function parameters for the largest industries in our sample.

[24]Foster et al. (2008) contrast TFPR with "technical efficiency." The latter characterizes the rate at which firms transform physical inputs into physical outputs. The former relates firms' ability to transform expenditures on inputs into revenues. Differing productivity measures may be more or less salient, depending on the context and question at hand. In terms of understanding the differential welfare impacts of the subsidy program, a task we turn to in Section 5, TFPR provides the relevant measure of productivity.

We amend the regression specifications from Equation 3 to include information on the share of the firm's customers or suppliers who have received a subsidy:

$$\begin{aligned} y_{ft} &= \beta_f + \beta_{nt} + \beta_1 S_{ft} + \beta_2 \cdot w_{npt} \\ &\quad + \beta_{\text{up}} s^{\text{upstream}}_{\vartheta \to ft} + \beta_{\text{down}} s^{\text{downstream}}_{f \to \vartheta, t} + \varepsilon_{ft} \ . \end{aligned} \tag{4}$$

In Equation 4, y_{ft} refers to a firm-year level activity measure (either log revenues, log employment, log investment, or TFP), $s^{\text{upstream}}_{\vartheta \to f}$ equals the share of firm f's intermediate input expenditures that are sourced from subsidized firms, $s^{\text{downstream}}_{\vartheta \to f}$ equals the share of firm f's intermediate input sales that are sold to subsidized firms, and w_{npt} equals the average daily wage in firm f's local labor market (i.e., the average wage paid by firms in industry n and province p in year t). In addition, we include province-industry fixed effects and controls for firm activity as of 2012. In certain specifications, we include firm fixed effects.

Tables 8 and 9 present our estimates of Equation 4. First, controlling for suppliers' and customers' subsidization and wages in the firms' local labor market yields similar estimates of the productivity gains from subsidization (compare the estimates in columns 7 and 8 of Table 9 to those in columns 6 and 7 of Table 7). Second, firms with more subsidized customers have higher revenues and employment. The relationship between firms' TFP and the fraction of their customers who are subsidized is not statistically significant. Third, the relationship between the share of a firm's suppliers who are subsidized and their economic activity is sensitive to the activity measure, with revenues and measured productivity yielding a positive estimated relationship and plant, property, and capital equipment yielding a negative relationship in certain specifications and a positive in others.[25] According to our IV estimates, a 5 percentage point increase in the fraction of a firm's suppliers and customers who are subsidized implies an increase in revenues of 0.7 percent, an increase in employment of 0.6 percent, and marginal changes in investment and marginal costs.[26]

5 Aggregate Implications

In this section, we examine the aggregate implications of the 2012 subsidy program. We focus on the impact of the reforms on regional real wage inequality. There are, indeed, other metrics that one could use to evaluate the effectiveness of the subsidy program: the costs of these subsidies, whether the reforms increased aggregate economic activity relative to these costs, and whether the reforms reduced overall wage inequality (including wage inequality within regions). However,

[25] Canonical models of input-output linkages, including Acemoglu et al. (2012), predict that decreases in a firm's marginal costs (e.g., through subsidization of inputs) will reduce the marginal costs of the firm's customers, but not their suppliers. This is consistent with the results in columns (7) and (8).

[26] To compute these numbers, multiply the 0.05 with the sum of β_1 and β_2, using the even-numbered columns. For instance, to compute the employment effect, take the numbers from column (4) of Table 9: 0.5 percent ($\approx 5 \cdot (0.097 + 0.020)$).

Table 8: The Impact of the Subsidy Program on Firm Activity: OLS Estimates

Dependent Variable	Revenues		Employment	
	(1)	(2)	(3)	(4)
Investment Tax Credit	0.698***	0.638***	0.958***	0.930***
Rate	(0.041)	(0.035)	(0.083)	(0.092)
Weight of Subsidized	0.100***	0.065***	0.115***	0.098***
Firms in Total Sales	(0.013)	(0.012)	(0.012)	(0.011)
Weight of Subsidized	0.104***	0.107***	0.030	0.020
Firms in Total Purchases	(0.015)	(0.014)	(0.020)	(0.017)
Log Daily Wage	0.055***	0.034***	0.002	0.012*
	(0.012)	(0.010)	(0.007)	(0.007)
N	841,453	841,453	842,514	842,514
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
R^2	0.850	0.854	0.875	0.879
Dependent Variable	Property, Plant, and Equipment Capital		TFP	
	(5)	(6)	(7)	(8)
Statutory Investment	1.771***	1.843***	-0.085***	-0.115***
Tax Credit Rate	(0.102)	(0.094)	(0.030)	(0.028)
Weight of Subsidized	0.021	0.015	0.001	-0.007
Firms in Total Sales	(0.015)	(0.014)	(0.007)	(0.007)
Weight of Subsidized	0.035	-0.006	0.053***	0.040***
Firms in Total Purchases	(0.028)	(0.019)	(0.011)	(0.012)
Log Daily Wage	0.059***	0.032**	-0.014*	-0.008
	(0.022)	(0.016)	(0.007)	(0.006)
N	825,682	825,682	791,523	791,523
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
R^2	0.892	0.895	0.643	0.654

Notes: All regressions include firm fixed effects. Standard errors are clustered at the province level.

as we have discussed earlier, a primary goal of the 2012 policy was to reduce the gap between the relatively low-wage southeast and the rest of the country, and so this is our primary object of interest.[27]

We develop a dynamic general equilibrium model with trade and migration across regions. Our model builds off of Kleinman et al. (2023), who show how one can tractably analyze dynamic capital investment and migration decisions in a model with many industries and regions. Our framework is ideally suited to appraise the short-run and long-run spatial spillovers resulting from increased subsidization concentrated in the eastern provinces of the country. Even if — as we have documented in the previous section — the subsidy program spurred investment

[27] Gaubert et al. (2021) discuss the motivations for place-based redistributive policies. Broadly, there are two classes of motivations: improving the equity-efficiency trade-offs involved in place-blind redistributive policies, and a *per se* societal goal for limiting poverty within distressed areas.

Table 9: The Impact of the Subsidy Program on Firm Activity: IV Estimates

	Revenues		Employment		Property, Plant, and Equipment Capital		TFP	
Second-Stage Estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment Tax Credit	2.535***	2.548***	0.971**	0.942	0.242	3.705***	1.041***	0.647***
Rate	(0.354)	(0.514)	(0.457)	(0.676)	(1.093)	(0.895)	(0.208)	(0.186)
Weight of Subsidized	0.095***	0.059***	0.115***	0.097***	0.026	0.009	-0.002	-0.009
Firms in Total Sales	(0.012)	(0.012)	(0.012)	(0.010)	(0.017)	(0.015)	(0.007)	(0.007)
Weight of Subsidized	0.068***	0.083***	0.030	0.020	0.065***	-0.031*	0.030**	0.030**
Firms in Total Purchases	(0.012)	(0.013)	(0.020)	(0.015)	(0.020)	(0.016)	(0.015)	(0.012)
Log Daily Wage	0.051***	0.034***	0.002	0.012*	0.063***	0.033**	-0.017***	-0.008
	(0.010)	(0.009)	(0.007)	(0.007)	(0.020)	(0.015)	(0.006)	(0.005)
N	791,598	791,252	792,671	792,326	778,944	778,596	744,754	744,384
Year FEs	Yes	No	Yes	No	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes	No	Yes	No	Yes
First-Stage Estimates								
Statutory Investment	0.137***	0.127***	0.137***	0.127***	0.138***	0.127***	0.137***	0.127***
Tax Credit Rate	(0.010)	(0.020)	(0.010)	(0.020)	(0.010)	(0.020)	(0.010)	(0.020)
Weight of Subsidized	0.002	0.002*	0.002	0.002*	0.003	0.002*	0.002	0.002
Firms in Total Sales	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Weight of Subsidized	0.017***	0.012***	0.017***	0.012***	0.018***	0.012***	0.018***	0.013***
Firms in Total Purchases	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Log Daily Wage	0.001	-0.001	0.001	-0.001	0.001	-0.001	0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Notes: All regressions include firm fixed effects. Standard errors are clustered at the province level.

in targeted regions, domestic trade flows, capital flows, and migration may blunt the policy's impact on inter-regional real wage inequality. A dynamic general equilibrium model is necessary to quantify the importance of these countervailing forces.

5.1 Overview

The model features firms, households, landlords, and investors each residing in a given location and tied to a particular industry. A location (or "region") refers to one of Turkey's six subsidy regions. An industry refers to one or a combination of NACE industries (with a total of 45 industries; see Appendix E.2 for the list of industries). And a period is a year.

Firms produce using labor, land, capital, and material inputs (see row 1 of Table 10). Firms' outputs are sold to consumers and to firms in other provinces. Firms in each region-industry pair are subject to exogenous productivity shocks. In addition, there are agglomeration effects: Firm productivity endogenously increases according to the total employment within its region-industry pair (see row 2). Households supply their labor and use their earnings to consume; they may also abstain from working (row 3). Households neither borrow nor save. Each period, households decide how much of each industry's product to consume and whether to migrate to a different industry-region pair (row 4). Both migration and flows of intermediate goods across industries and geographies are costly: Households face a utility cost of switching the industry and region in which they are employed (row 5). Shipments across regions are subject to iceberg trade costs (row 6). Capital investors — who are indexed to the region and industry in which they reside — choose how much to invest in capital in every period and how much to consume; their preferences are specified in rows 8 and 9. They allocate their capital investments across different region-industry pairs, potentially with an (exogenously specified, given by the $\phi_{ih \to nj}$ in row 10) higher share of investments in their home region. The model features "capital returns wedges," $\tau^K_{nj,t}$. These wedges alter the returns that capital investors earn in each region-industry pair. As in Caliendo et al. (2019), landlords earn income from the land that they rent to firms in each region-industry pair. We assume that landlords (who, reside throughout the country) each own a share of a national portfolio of the total land stock. Finally, region i's sales of each industry j output eqauls consumption expenditures — by workers, capital investors, and landords — plus sales as intermediate inputs (row 12).

These model ingredients allow us to explore the different channels through which subsidies may dissipate across geographies or industries. First, subsidization of firms in a particular region will lead to in-migration from unsubsidized regions, partially offsetting the real wage gains from the subsidy-induced increase in labor demand. Second, input-output linkages imply that shocks increase factor demands in both the directly affected industry-region pair and in industry-regions that are upstream or downstream of the subsidized firms. Third, subsidization pushes up rental prices in the affected region. To the extent that investors' capital and landlords' land are located elsewhere in the country, subsidies targeting one region will increase income —

Table 10: Partial Overview of the Model

(1)	Production technology	$\mathbb{C}_{it}^{j}=\left[\left(\frac{w_{it}^{j}}{z_{it}^{j}}\right)^{\mu^{j}}\left(r_{it}^{j}\right)^{1-\mu^{j}-\alpha^{j}}\left(\tilde{r}_{it}^{j}\right)^{\alpha^{j}}\right]^{\gamma^{j}}\prod_{h=1}^{J}\left(p_{it}^{h}\right)^{\gamma^{j,h}}$
(2)	Agglomeration economies	$z_{it}^{j}=\overline{z}_{it}^{j}\left(\overline{l}_{it}^{j}\right)^{\eta}$
(3)	Worker instantaneous utility	$\log u_{it}^{j,w}=\log b_{i}^{j}+\sum_{h=1}^{J}\psi^{h}\frac{\theta+1}{\theta}\log\left[\sum_{n=1}^{N}\left(c_{n,i,t}^{hj,w}\right)^{\theta/(\theta+1)}\right]$
(4)	Worker value function	$\mathbb{V}_{it}^{j,w}=\log u_{it}^{j,w}+\max_{g,h}\left\{\beta\mathbb{E}_{t}\left[\mathbb{V}_{g,t+1}^{h,w}\right]-\kappa_{gi}^{hj}+\rho\varepsilon_{gt}^{h}\right\}$
(5)	Bilateral migration costs	$\kappa_{gi}^{hj}\geq 1;\ \kappa_{ii}^{jj}=1$
(6)	Bilateral trade costs	$\tau_{gi}^{j}\geq 1;\ \tau_{ii}^{j}=1$
(7)	Labor market clearing	$\sum_{i=1}^{N}\sum_{j=0}^{J}\ell_{ij}=1$
(8)	Investor intertemporal preferences	$\mathbb{V}_{it}^{j,k}=\sum_{t=0}^{\infty}\beta^{t}\log C_{i,t}^{j,k}$
(9)	Investor instantaneous utility	$\log C_{i,t}^{j,k}=\sum_{h=1}^{J}\psi^{h}\frac{\theta+1}{\theta}\log\left[\sum_{n=1}^{N}\left(c_{n,i,t}^{h,j,k}\right)^{\theta/(\theta+1)}\right]$
(10)	Investor Income	$\log\mathcal{R}_{i,t}^{h}=\sum_{n=1}^{N}\sum_{h=1}^{J}\phi_{ih\rightarrow nj}\log\left[r_{nt}^{j}\cdot\left(\tau_{nj,t}^{K}\right)^{-1}\right]$
(11)	Capital Accumulation	$\mathcal{K}_{i,t+1}^{j}=(1-\delta)\,\mathcal{K}_{i,t}^{j}+\sum_{h=1}^{J}\sum_{n=1}^{N}\iota_{n,i,t}^{h,j}$
(12)	Goods market clearing	$y_{it}^{j}=\sum_{n=1}^{N}S_{nit}^{j}\left[\psi^{j}\left(\sum_{h=1}^{J}\left(w_{nt}^{h}\ell_{nt}^{h}+r_{nt}^{h}k_{nt}^{h}+\tilde{r}_{nt}^{h}\tilde{k}_{nt}^{h}\right)\right)+\sum_{h=1}^{J}\gamma^{h,j}y_{nt}^{h}\right]$

Notes: This table summarizes the model's key equations. Here i and g denote locations, h and j denote industries (with $j=0$ reserved for non-emplolyment). Furthermore, $\mathbb{C}$ denotes the marginal cost of production; $\overline{z}_{i,t}^{j}$, exogenous productivity; $z_{i,t}^{j}$, endogenous productivity; k, capital that is rented by each industry-region pair (at rental price r); $\widetilde{k}$, land that is rented by each industry-region pair (at rental price $\widetilde{r}$); w, the wage in each region-industry pair; p, the price of material inputs; u, period utility; $\mathbb{V}$, lifetime utility; b, the amenity value of living in a given region-industry pair; $c_{\cdot,\cdot}^{\cdot,\cdot,w}$, consumption of workers; $c_{\cdot,\cdot}^{\cdot,\cdot,k}$, consumption of capital investors; $c_{\cdot,\cdot}^{\cdot,\cdot,r}$, consumption of landlords; τ^{K}, shifts to capital returns; $\mathcal{R}_{i,t}^{h}$, the return on capital earned by industry h, industry i capital investors; $\mathcal{K}_{i}^{j}$ = the capital stock held by industry j region i investors; ι, capital investment; S_{nit}^{j}, the share of location n's expenditures on industry j that are sourced from region i; and y_{it}^{j}, region i's expenditures on industry j output. The model parameters include the cost share of labor in value added (μ), the cost share of land in value added (α), the cost share of value added in gross output (γ), the cost share of commodity h in gross output ($\gamma^{\cdot,h}$), the importance of different industries in period utility (ψ), the strength of agglomeration economies (η), the trade elasticity (θ), the dispersion of idiosyncratic mobility costs (ρ), the discount factor (β), the share of region-industry (ih) investors' capital that is allocated in destination region-industry (nj) $\phi_{ih\rightarrow nj}$, and the capital depreciation rate (δ). For additional detail, see Appendix E.1.

Table 11: Overview of Calibration

	Moment	Data Source and Description
(1)	Subsidy Take-up and generosity	Investment tax credits received by year-industry-region
(2)	Direct productivity effect of subsidy on firm productivity	Column (8) of Table 9, or Table 5
(3)	Trade flows across regions and industries	See Figure 2
(4)	Labor flows across regions and industries	See Figure 3
(5)	Labor costs, value added, and gross output by industry and region	Turkish National Input-Output Tables from the World Input-Output Database
(6)	Consumption preference shares by industry and region	Turkish National Input-Output Tables from the World Input-Output Database
(7)	Materials purchases by upstream industry×downstream industry×destination region	Turkish National Input-Output Tables from the World Input-Output Database
(8)	Land share of capital	Fernald (2015): $\alpha/(1-\mu) = 0.1$
(9)	Agglomeration externality: Sensitivity of firms' productivity to region-industry employment	Combes and Gobillon (2015): η=0.05

Notes: This table gives a brief description of our model calibration. For additional detail, see Appendix E.2.

and, as a result, consumption, labor demand, and real wages — elsewhere.

5.2 Calibration

Table 11 summarizes the moments and data sources necessary to calibrate our model. Most of the moments can be taken from observed data: from trade and migration flows across regions and industries in the pre-policy period, and from the Turkish National Input-Output Tables.

Of particular importance for our consideration of the counterfactual economy are our estimated direct impacts of the subsidy program on the time paths of labor productivity and the returns to capital. We pursue two complementary strategies to infer this critical set of parameters.

For either of the two strategies, we do not model the costs associated with the subsidy program. To the extent that the introduction of new subsidies prompts the national government to raise taxes, borrow, reduce government expenditures, or inflate there will be countervailing effects relative to the ones reported here. So long as these countervailing effects manifest uniformly across geographies (e.g., the prompted tax increases are neither location- nor industry-specific), our results on regional inequality will be unaffected by modeling the policy-related costs.

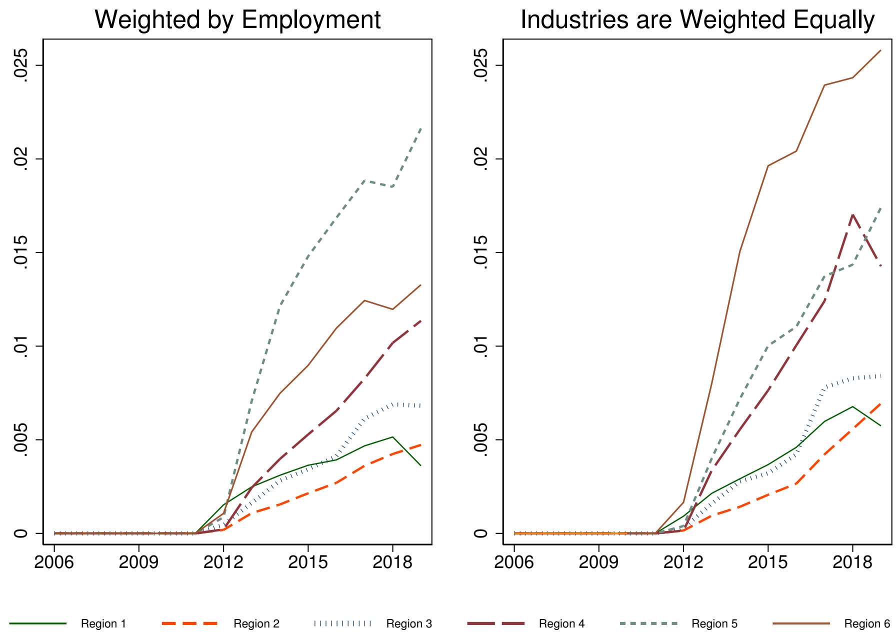

Figure 5: Investment Tax Credit Rates
Notes: The left panel gives the employment-weighted average investment tax credit rates for each region and year. In the right panel, industries are weighted equally within each region-year pair.

Relating Subsidy Take-up to Productivity and Capital Returns

In our primary approach to calibrate the direct impact of the subsidy program, we combine information on subsidy take-up rates (as measured by the investment tax credit rates in each region-industry pair) and the relationship between subsidization and TFP. While our regressions in Section 4 focused on investment tax credits as the measure of firm subsidization, we emphasize that subsidies to capital investment and hiring labor are bundled with one another, so the subsidy program applies both to capital and labor.[28] In the context of our model, we let the policy to augment labor productivity ($\overline{z}$) and capital returns ($1/\tau^K$) in proportion to the TFP impacts identified in Section 4, with the relative effects on labor productivity and capital returns determined by the allocation wage and capital investment subsidies.

Figure 5 presents the time path of subsidies received by region. For each industry, we compute the product of subsidy take-up rates multiplied by the investment tax credit rate

[28] In a previous version of our paper (Atalay et al., 2023), we applied the Caliendo et al. (2019) framework to assess the aggregate implications of the 2012 subsidy policy. In Caliendo et al. (2019), firms produce using labor, material inputs, and land. There is no dynamically adjusting capital stock. When subsidies in a region increase, labor flows into that region, reducing the land-to-labor ratio and putting downward pressure on real wages there. Consequently, the long-run national increase in real wages is smaller with the Caliendo et al. (2019) model. So, too, is the impact on long-run regional inequality. However, our main conclusion — that trade and migration flows considerably dampen the policy's impact on reducing regional real wage inequality — is consistent across both the Caliendo et al. (2019) and Kleinman et al. (2023) models.

for firms successfully applying for the credit. Then, for each subsidy region, we compute the average across industries.[29] Within the left panel, we weight industries by employment; within the right panel all industries are weighted equally. From 2012 on through the remainder of our sample, statutory subsidy generosity is constant. The changes in regional subsidies seen in the figure come instead from shifts in the fraction of firms who receive investment tax credits. This fraction rises quickly from 2012 to 2016, and then decelerates in the final couple years of our sample. Regions 5 and 6 benefited the most from the subsidy program, with Regions 1, 2, and 3 receiving the lowest levels of subsidization.[30] Region 6's employment in construction, manufacturing, waste collection and waste management is substantially lower than in other industries. As a result, the average investment tax credits received in Region 6 is smaller than that in Region 5, despite substantially greater statutory rates in Region 6.

To infer the direct productivity impact of the subsidy program, we multiply the industry-region-specific time series of the average investment tax credit rates received by 0.647 (see column 8 of Table 9). Call this s_{ijt}. This is the incremental productivity gain from the investment tax credit. While Table 9 includes one summary measure of increased productivity, in our model there are two avenues through which the subsidy program has an impact. Approximately one-third of the expenditures of the subsidy program consisted of rebates on mandatory social security payments; two-thirds were reductions in corporate taxes in proportion to capital investments. As a result, using the calibration of$\mathrm{d}\log \overline{z}^j_{it} = \kappa_z \frac{s_{ijt}}{\gamma^j \alpha^j}$ and $\mathrm{d}\log \tau^K_{ij,t} = -\kappa_\tau \frac{s_{ijt}}{\gamma^j (1-\mu^j-\alpha^j)}$, we set $\kappa_z = \frac{1}{3}$ and $\kappa_\tau = \frac{2}{3}$.

Matching Observed Revenue and Employment Growth to that in Our Calibrated Model

One concern regarding the "micro approach" from the previous subsection is that there may be spillovers across treated and untreated firms, leading us to violate the "stable unit treatment value assumption" (SUTVA) (Angrist et al., 1996). We directly control for subsidization of the firms' customers or suppliers, to potentially account for spillovers across firms sharing production links, and average wages in the firm's province-year-industry, to account for the possibility that

[29] We abstract from the substantial heterogeneity which exists in subsidy take-up rates (and productivity gains from subsidies) within industry-region pairs. (Moreover, these within-industry×region differences exist partly on the basis of observable firm characteristics. For example, firms with more employees are more likely to successfully apply for a subsidy.) While interesting, these differences are not of first order-importance for our analysis of regional income inequality.

[30] In Appendix D.3, we supplement Figure 5 with two additional figures. First, we plot average investment tax credits received by industry and subsidy region at the end of our sample period. According to this figure, subsidization was greatest in construction (NACE B); textile, apparel, and leather manufacturing (NACE C13-C15); computer and electronic products manufacturing (NACE C26), transportation manufacturing (NACE C29, C30); and education (NACE P85), with subsidization uniformly higher in Regions 5 and 6 relative to Regions 1 and 2. Second, we plot average investment tax credits received among firms in the formal economy. (Figure 5 presents a weighted average of subsidization in the informal economy — firms who were ineligible to receive subsidies — and that in the formal economy.) There, our measures of subsidization are greater by a factor of two to three, with the biggest discrepancy in Region 6 (a region in which informal-sector firms are over-represented).

the subsidy drove up wages in the firms' local labor market (increasing marginal costs, and thus lowering their measured productivity.) While the inclusion of these controls mitigate SUTVA-related concerns, it is possible that there are other unobserved spillovers that we are not able to control for.

As an alternate strategy to calibrate $\mathrm{d}\log \overline{z}_{it}^{j}$ and $\mathrm{d}\log \tau_{i,t}^{j,K}$, we consider an "indirect inference" approach. We regress (i) industry-region level revenues and employment against subsidy measures in our data; and (ii) industry-region level revenues and employment against subsidy measures in our model. We match (i) and (ii) to calibrate the extent to which lower investment tax credit rates translate to increases in $\overline{z}$ and reductions in τ^K. Our objective with our indirect influence approach is to accommodate any unmodeled spillovers between treated and untreated groups. To the extent that such spillovers show up in industry-region pairs' employment or revenues — two key endogenous observable variables in our model — our estimation will account for them.

In more detail, we consider regressions of the form:

$$\begin{aligned} y_{rnt} &= \delta_{rn} + \delta_{nt} + \delta_1 S_{rnt} + \varepsilon_{rnt} \ . \\ \ell_{rnt} &= \vartheta_{rn} + \vartheta_{nt} + \vartheta_1 S_{rnt} + \epsilon_{rnt} \ . \end{aligned} \tag{5}$$

Here, r denotes a subsidy region, n denotes a 2-digit industry (or a combination of 2-digit industries) and t denotes a year. Furthermore, y_{rnt} denotes either observed log revenues or log revenues in the model equilibrium. Similarly, ℓ_{rnt} denotes the observed (or model equilibrium) value of log employment in region r, industry n, and year t. In different regression specifications, we apply different sets of fixed effects (either year and region×industry or, alternatively, year×industry and region×industry) and either weight observations according to the number of firms in the industry-region pair or weight all observations equally.

In Table 12, we present our estimates of Equation 5. Panel A presents results from industry-level data. In all specifications, subsidization is associated with higher revenues and employment, though the coefficient estimates for employment are not statistically significant in the unweighted specifications.

Panel B presents counterfactual impacts from our model, in which we feed in exogenous productivity and capital returns changes in industry-region pairs to be proportional to investment tax credits received in the industry-province pair. We choose the two constants of proportionality (one for labor productivity, the other for capital returns) so that the impacts of subsidization match what we observed in panel A.[31,32]

[31] We assume that agents did not anticipate, in 2011 or before, the subsidy program being enacted in 2012. As a result, the counterfactual impact of the subsidy program on revenues were 0 for $t = \{2006, ..., 2011\}$.

[32] Let $\beta^A_{(x)}$ refer to the coefficient in column (x) in panel A and $\beta^B_{(x)}$ the corresponding coefficient estimate from panel B. We choose non-negative values of κ_z and κ_τ to minimize $\sum_{x=1}^{8} \left(\beta^A_{(x)} - \beta^B_{(x)}\right)^2$. The resulting values of κ_z and κ_τ are 2.351 and 0, respectively.

Table 12: Estimates of Equation 5

Panel A: Data	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Revenues				Employment			
Investment Tax Credit	4.685***	6.436***	1.676	2.517	2.425	5.544**	-0.008	2.201
Rate	(0.431)	(0.716)	(1.211)	(1.661)	(1.882)	(2.013)	(1.686)	(2.392)
Weight Observations?	Yes	Yes	No	No	Yes	Yes	No	No
Year FEs	Yes	No	Yes	No	Yes	No	Yes	No
Industry × Year FEs	No	Yes	No	Yes	No	Yes	No	Yes
N	3,660	3,660	3,660	3,660	3,589	3,588	3,589	3,588
R^2	0.987	0.996	0.949	0.974	0.985	0.996	0.947	0.979
Panel B: Counterfactual	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Dependent Variable	Revenues				Employment			
Investment Tax Credit	4.540***	4.204***	3.747***	3.315***	1.737	4.104***	2.236**	2.816***
Rate	(0.362)	(0.627)	(0.646)	(0.772)	(1.079)	(0.752)	(0.616)	(0.688)
Weight Observations?	Yes	Yes	No	No	Yes	Yes	No	No
Year FEs	Yes	No	Yes	No	Yes	No	Yes	No
Industry × Year FEs	No	Yes	No	Yes	No	Yes	No	Yes
N	3,660	3,660	3,660	3,660	3,660	3,660	3,660	3,660
R^2	0.757	0.877	0.799	0.869	0.643	0.779	0.717	0.796

Notes: All regressions additionally include region-industry fixed effects. Standard errors are clustered at the region level.

5.3 Aggregate Impacts on Employment, Capital, and Real Wages

We next report the results from our calibrated model. We first apply our Section 4.4 regressions to calibrate the direct impacts of the 2012 subsidy program on productivity and capital wedges. We then consider an "indirect-inference" approach to calibrate these moments. The section closes with a brief description of additional sensitivity analyses. Our counterfactual exercises require, as inputs, expected values for labor-augmenting productivity and capital wedges beyond the end of our sample period. We assume that after 2019 the subsidy levels (and, consequently, the direct productivity and capital returns impacts of the subsidy program) are equal to their 2019 values. We depict equilibrium outcomes for each year up to 2040. Even though there are no new "shocks" beginning in 2020 that we feed into the model, the dynamics of migration and capital accumulation continue to play out slowly over time.

Calibration Based on Estimates from Table 9

Our first set of results assesses the effect of the subsidy program on migration and employment by region. Figure 6 shows the model-implied population, labor force, and capital-labor ratio in each region compared to a scenario without the subsidy. Looking one decade after the policy's introduction, as of 2022, the subsidy increases the population by 0.8 percent in Region 6 and 1.8 percent in Region 5, while Regions 1 and 2 sees declines of 0.1 percent and 0.3 percent, respectively. These effects grow over time, with Region 5's population rising by 3.4 percent and Region 2's declining by 0.6 percent by 2040. In the top right panel, we plot employment by subsidy region. Across all regions, the subsidy program increases the returns to work relative to non-employment, leading to higher employment-to-population ratios throughout the country, but especially in Regions 5 and 6. As of 2040, employment increases by 4.7 percent in Region 6 and 6.0 percent in Region 5; it increases by 0.8 percent in Region 2 and 1.2 percent in Region 1. The bottom left panel plots the capital to labor ratio resulting from the subsidy program, which increases throughout the country, with the largest gains in Region 5.

Our second set of results considers the impact of the subsidies on regional real wage inequality. The top left panel of Figure 7 presents results for the benchmark calibration, with domestic input-output linkages, migration, and investors who hold capital in regions other than where they reside. The 2012 subsidy scheme increases real wages most in Regions 4, 5, and 6 (the most heavily subsidized regions) and the least in Region 1. By 2022, real wages increases by 0.9 percent in Region 1 and 1.8 percent in Region 5. Thus, as of 2022, we surmise regional wage inequality declines by 0.9 percent as a result of the subsidy program. Over time, capital deepening increases real wages, especially so in Region 5, while migration — by increasing labor supply more in heavily subsidized areas — acts as a countervailing force. We forecast that the program's subsidies will have reduced regional inequality by 0.9 percent as of 2030 and 1.1 percent as of 2040.

To understand the modest impacts on real wage inequality, we consider three additional

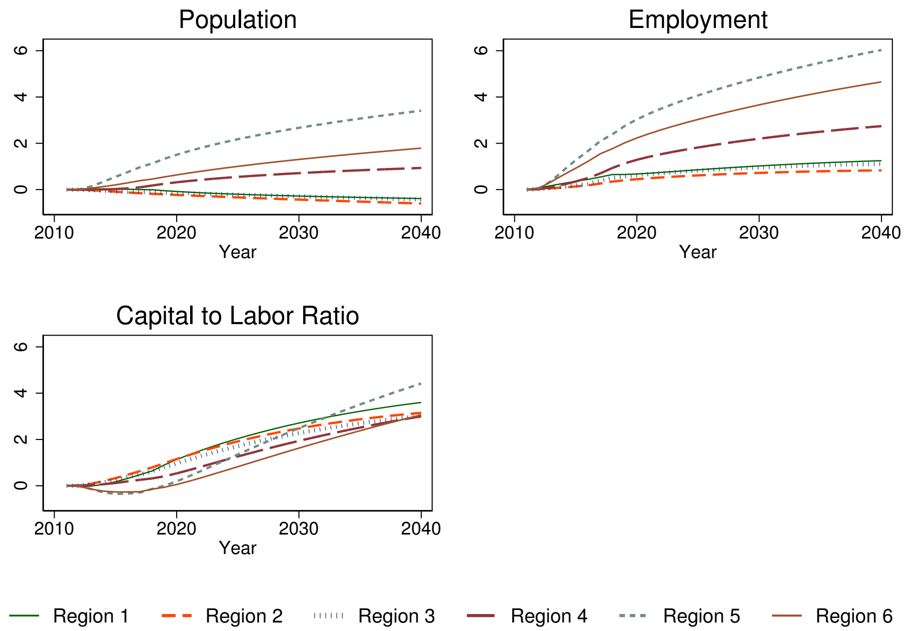

Figure 6: Migration, Employment, and Capital-Labor Ratio Effects of the 2012 Subsidy Program
Notes: This figure presents the employment, migration, and capital effects of the subsidy program. The top left panel describes the trajectory of population in each subsidy region. The top right panel describes employment in each region. And the bottom left panel describes the impact of the subsidy policy on capital-labor ratios in each subsidy region. We compute regional aggregates by computing weighted means across industries, using employment as of 2012 within the region as weights.

model calibrations, progressively restricting spillover channels. In our second calibration (labeled "No Migration" in Figure 7), we restrict migration across subsidy regions. (People may still switch industries.) In the third (labeled "No Migration, Autarky"), we additionally restrict inter-regional trade flows. In the fourth and final calibration (labeled "No Migration, Autarky, No Capital Flows"), we assume that investors only hold capital in the regions in which they reside. These calibrations aim to highlight the importance of trade, migration, and capital income spillovers in shaping the policy's ability to reduce regional inequality.

Comparing the top two panels of Figure 7 highlights the role of migration in shaping wage inequality: Absent inter-regional migration, the program's subsidies would have reduced Region 5 versus Region 1 real wage inequality by 1.4 percent as of 2022, 1.6 percent as of 2030, and 1.9 percent as of 2040. In a world without trade flows across regions, this calibration indicates that the impact of the subsidy program on real wage inequality (now comparing Region 6 and Region 1) would have been even greater: 1.5 percent, 2.0 percent, and 2.8 percent as of 2022, 2030, and 2040, respectively (see the bottom left panel). Excluding capital flows across regions, the policy reduces 2022, 2030, and 2040 inequality by 2.1 percent, 2.9 percent, and 3.6 percent,

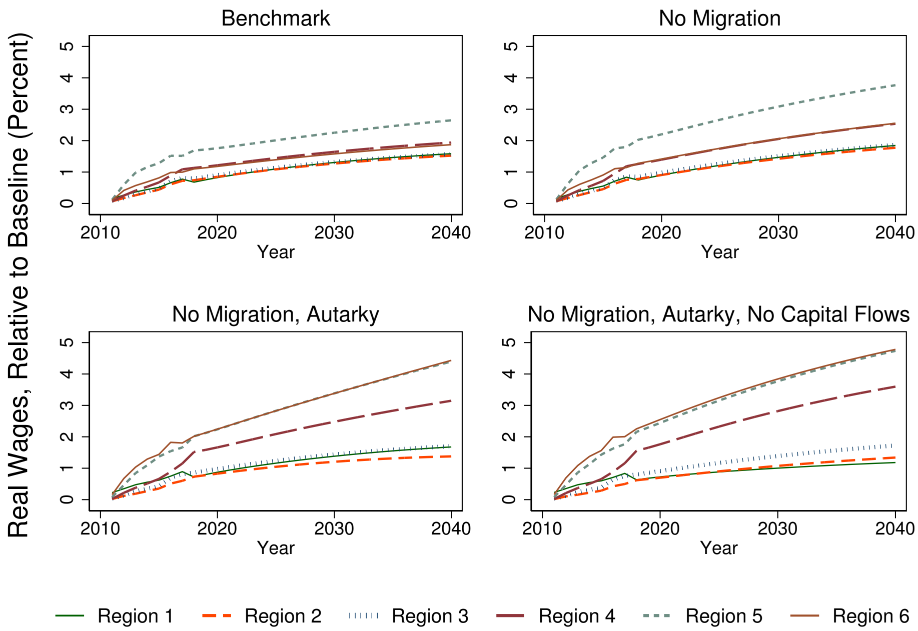

Figure 7: Real Wage Effects of the 2012 Subsidy Program
Notes: Each of the four panels display real wage trajectories for a separate model calibration. Real wages within each region are averages among employed individuals, using baseline employment to weight within each region. Compared to the top left panel, in the top right panel, our calibration imposes that workers may not migrate across subsidy regions (they may still move across industries within their regions). In the bottom left panel, we additionally impose that there are no material goods purchases across subsidy regions (input-output linkages still exist within regions). Finally, in the bottom right panel, we assume capital investors hold only capital within their own region.

respectively (see the bottom right panel).[33]

Table 13 compiles the impacts of the 2012 policy on regional real wage inequality over different horizons in these calibrations (and those discussed in the following subsection). In sum, we find that the 2012 policy had a modest impact on regional real wage inequality in the short run, though a somewhat larger impact in the long run. Spillovers — through capital, migration, and trade flows traversing Turkey's six subsidy regions — blunt the policy's impact in reducing regional inequality. These results highlight the limits of a common approach in the place-based literature to study spillovers, which involves progressively applying progressively broadening

[33]The fact that a substantial portion of the potential real wage gains induced by the subsidies is dissipated through migration to subsidized areas (this could be a combination of reduced out-migration and in-migration) raises interesting questions about the Turkish government's views on desired outcomes of the program. Namely, would it find a "quantity" rather than "price" response—stemmed depopulation in place of reductions in per capita income gaps—acceptable, and at what rate would it be willing to trade one for the other? Such a trade-off is plausible. There is some evidence that the government believes İstanbul congestion is socially costly and might want to relieve migratory pressure (Milliyet, 2022). Further, to the extent that agglomeration economies, at least on the margin, were stronger in poorer regions than in wealthier ones, limiting migration might be an additional benefit.

Table 13: Real Wage Effects of the 2012 Subsidy Program

Year	2015	2020	2025	2030	2035	2040
Panel A: Calibration Based on Estimates from Table 9						
Baseline	0.8	0.9	0.9	0.9	1.0	1.1
No Migration	0.9	1.3	1.5	1.6	1.8	1.9
No Migration, Autarky	0.8	1.4	1.7	2.0	2.4	2.8
No Migration, Autarky No Capital Flows	1.0	1.8	2.4	2.8	3.2	3.6
Panel B: Calibration Based on Estimates from Table 12						
Baseline	5.2	6.0	5.4	5.3	5.4	5.5
No Migration	6.1	8.2	8.6	9.1	9.6	10.1
No Migration, Autarky	5.4	8.7	10.1	11.6	13.3	15.2
No Migration, Autarky No Capital Flows	5.5	9.3	10.9	12.4	13.7	14.9

Notes: Each cell presents the decrease in regional inequality — measured as the relative increase in real wages in the region experiencing the greatest increase in real wages (either Region 5 or Region 6) relative to the increase experienced by Region 1 — in different calibrations at different horizons.

regional and industry definitions in difference-in-difference frameworks. While a large fraction of spillovers occur among neighboring provinces, our analysis reveals that a significant share of migration and trade flows extend across Turkey.

Calibration Based on Estimates from Table 12

Figures 8 and 9 present the migration, employment, capital, and real wage effects of the subsidy program using our "indirect inference" approach. As this calibration imposes a larger effect of subsidization on productivity, we find larger effects on migration and real wages in Figures 8 and 9 than in Figures 6 and 7. According to the top left panel of Figure 8, the subsidization led to a decrease in real wage inequality (between Region 5 and Region 1, as of 2040) of approximately 5.5 percentage points. Besides the larger overall impacts, our main conclusions from Figure 6 also pertain to Figure 8: The impacts of the 2012 policy on regional real wage inequality are larger in the long run than in the short run. Spillovers across regions due to capital flows, migration, and trade are important in limiting the effectiveness of the subsidies on reducing regional inequality.

Additional Sensitivity Analyses

In this subsection, we briefly describe additional sensitivity analyses that are found in Appendix D.3.

In our baseline calibration, we associated the subsidy policy with an increase in labor productivity and investors' returns to capital, assigning their relative magnitudes based on the one-third/two-thirds split in subsidy expenditures. Figures 18 and 19 depict the program's impact on real wages under two extreme scenarios: one where the effect is through labor pro-

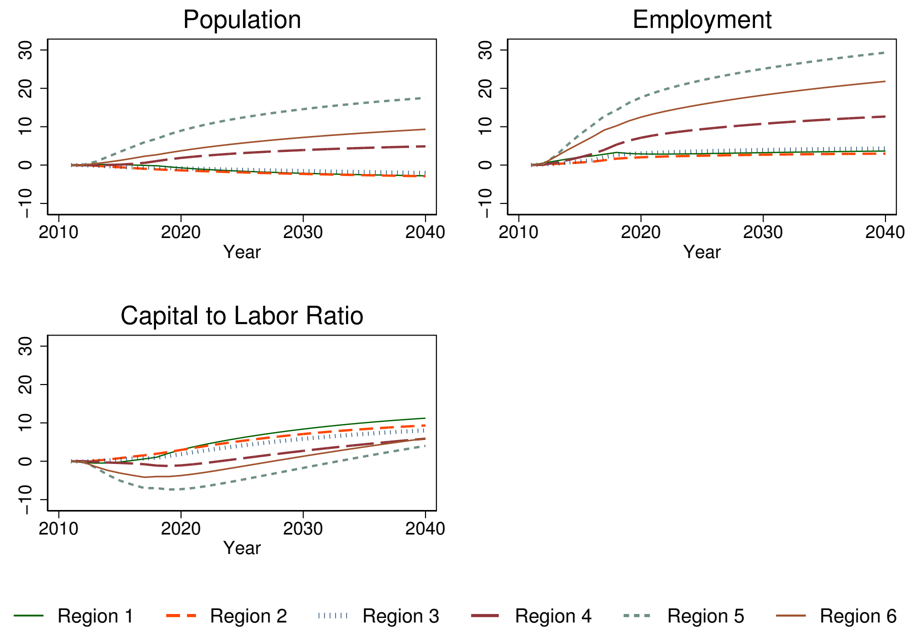

Figure 8: Migration, Employment, and Capital-Labor Ratio Effects of the 2012 Subsidy Program
Notes: See the notes for Figure 6. In contrast to that figure, here we use estimates from Table 12 to estimate the gains from the subsidy program.

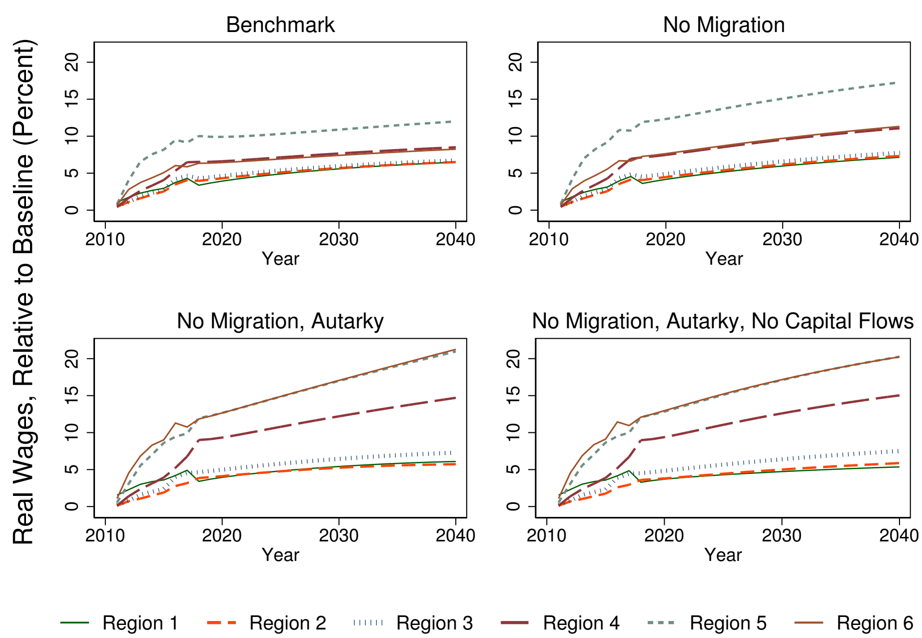

Figure 9: Real Wage Effects of the 2012 Subsidy Program
Notes: See the notes for Figure 7. In contrast to that figure, here we use estimates from Table 12 to estimate the gains from the subsidy program.

ductivity (Figure 18) and another through shocks to capital returns (Figure 19). The policy has a greater initial impact under the assumption that impacts are through labor productivity.

In Figure 20, we demonstrate that our results on the real wage impacts of the subsidy policy are robust across reasonable alternate choices on the strength of agglomeration economies. The impact of the policy is somewhat stronger for smaller values of the land share of capital, especially in the long run. Land, unlike reproducible capital, acts as a congestion force. With a higher land share, increased labor in regions 5 and 6 implies lower land per worker, acting as a countervailing force on the direct impacts of the policy.

Lastly, Figure 22 highlights the importance of accounting for informality and imperfect coverage in our micro data. That is, when we compute average investment tax credits received, trade and worker flows across subsidy region-by-industry pairs, we re-calibrate our model assuming (incorrectly) that the share of firms and employment in the informal sector are equal to 0 and that our firm-level data comprehensively measured all activity within each industry. We find that the real wage impacts of the subsidy program are considerably larger, primarily because this calibration ignores the roughly 30 percent of the economy that is ineligible to receive subsidies. However, again, we find that the impact of the subsidy program is blunted by the trade, capital income, and worker flows that traverse subsidy regions.

5.4 Out of Sample Predictions

In this section, we assess the model's ability to match two sets of non-targeted variables. We compare the model's predictions on the effects of the subsidy program on employment and revenues with the observed time paths of these two variables in the data. The overlap between the model-implied predicted effects on employment and revenues and those observed in the data serves as a diagnostic on our model and its calibration. Since our "indirect inference" approach to identify the link between investment tax credits and firm productivity relies on the relationship between industry-region revenues and subsidization, we only assess predicted effects based on our firm-regression-based calibration.

Figure 10 presents our main comparison. In this comparison, we classify industries as "subsidized" if their average investment tax credit rate exceeded 1.0 percent in 2017-2019, and "unsubsidized" otherwise.[34] For each set of industries, for each subsidy region, we compute the predicted sales growth (left panel) or employment growth (right panel), comparing 2011 to

[34] The list of subsidized industries includes the mining sector (NACE B), the waste management sector (NACE E), and the education sector (NACE P). In addition, all industries within the manufacturing sector (NACE C) with the exception of wood products (NACE C16), paper (NACE C17), printing and reproduction of recorded media (NACE C18), coke and refined petroleum products (NACE C19), rubber and plastics (NACE C22), fabricated metal products (NACE C25), and furniture and other manufactured products (NACE C31, C32) have an average investment tax credit rate greater than 1.0 percent. Furthermore, and for this section only, we drop the four sectors of the economy which for which the EIS microdata sample has poor coverage: Agriculture, Forestry, and Fishing (NACE A); Finance and Insurance (NACE K); Real Estate (NACE L); and Public Administration (NACE O).

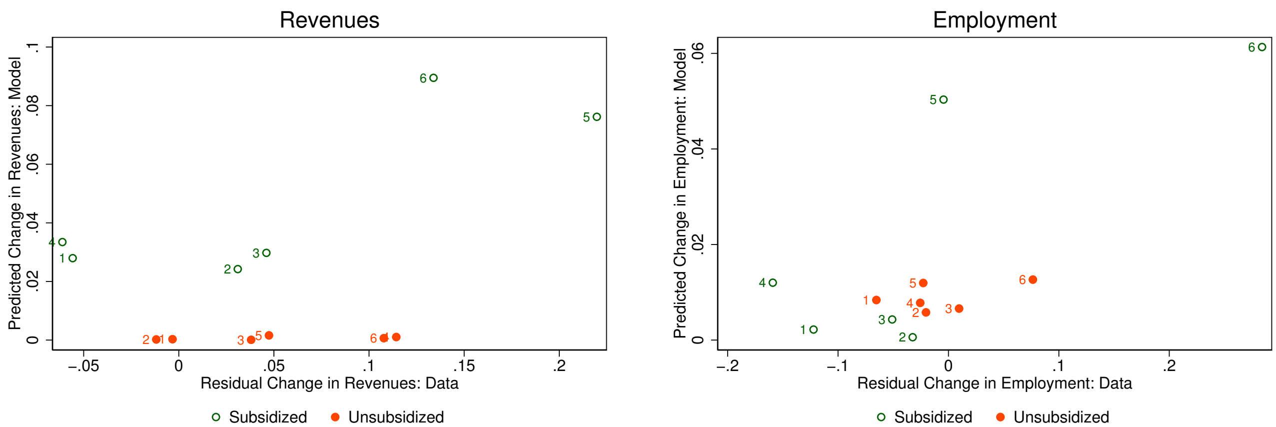

Figure 10: Subsidization, Employment, and Revenues: Model and Data
Notes: Within each panel, the vertical axis gives the model-implied increase — as of 2017-2019, relative to 2011 — in revenues (or employment), relative to a economy in which the subsidy program had not been enacted. The horizontal axis gives the average residuals, from a regression with log revenues (or log employment) as the dependent variable and industry-by-subsidy-region pair and year fixed effects as the covariates.

2017-2019. According to our model, subsidized firms in Region 6 increased their employment by 6.1 percent, and their output by 8.9 percent. In contrast, unsubsidized firms in the same region had output growth of 0.1 percent and employment growth of 1.3 percent. We compare these predicted sales and employment growth to their counterparts in the data. To compute this data counterpart, we regress industry-region pair log revenues against industry-region fixed effects and year fixed effects. From this regression, we compute the average residual (from 2017 to 2019) for each region, separately for "subsidized" and "unsubsidized" industries. Overall, we find a strong relationship between this average residual and the model prediction: The correlation between the model-implied impact of the policy and its data counterpart is 0.71 for revenues and 0.47 for employment. The difference in growth rates between subsidized industries in Regions 5 and 6 and others is larger in the data — at least twice as large — than predicted by the model, though this divergence between model and data may not be statistically significant.[35]

[35]We resample from our dataset of year-industry-subsidy regions 500 times. For each iteration, we estimate the regressions described above. We then, again, compute the average residual by subsidy region and subsidized-vs.-unsubsidized status pairs. For subsidized industries in Region 5, a 90% confidence interval for revenues spans 0.02 to 0.41; for Region 6, the analogous confidence interval spans -0.02 to 0.20. For subsidized industries in Region 6, a 90% confidence interval for revenues spans 0.09 to 0.49. So, even absent other sources of uncertainty, the scale of the policy's impact is not significantly greater in the data than in our counterfactual.

6 Conclusion

This paper examines the introduction of place-based policies in Turkey. These new subsidies were aimed at promoting economic activity, particularly in the relatively impoverished southeast of the country. We find that each 5 percentage point increase in investment tax credit subsidy rates increased firms' revenues, employment, and TFPR by 16.2 percent, 8.7 percent, and 3.3 percent, respectively. However, our general equilibrium analysis reveals that the 2012 subsidy program had only a modest impact on regional inequality.

There are several caveats to these conclusions. First, as with any piece of research focused on a single historical episode, there are limits to the generalizability of the paper's conclusions to other environments. Among the many unique features of the backdrop to our study, the period after the subsidies were introduced coincided with a large influx of refugees due to the 2010s Syrian Civil War and a significant devaluation of its currency, with the impacts of these events likely differing by geography and industry.[36,37] Given these aspects, a similarly designed set of subsidies may conceivably have a different impact in other countries. Second, the calibration of our Section 5 model requires information on subsidy take-up rates. To understand the long-run impact of the subsidy program, we necessarily extrapolated take-up rates beyond the end of our sample period. We assumed a leveling off of the fraction of firms who received subsidies from the Turkish government. However, other reasonable assumptions would lead to an alternate assessment of the policy's long-run impact.

While these are valid points, many of the lessons from our analysis may prove useful under other assumptions and in other contexts. Inter-regional spillovers — migration, input-output, and capital income linkages — limit how much the place-based policy specifically benefited the targeted region. We argued, further, that the effects may differ in the short and long run. In the short run, migration across regions is limited; the capital stock is fixed. In the long run, however, capital deepening further increases labor productivity in subsidized areas, while increases in labor supply to more heavily subsidized regions mute the impact of the subsidy program on inter-regional real wage inequality. Since capital deepening and inter-regional trade and migration flows are common features, these insights on the short- and long-run impacts of place-based policies on regional income inequality are likely to be broadly applicable.

[36] Between January 2007 and January 2012, the Turkish Lira lost approximately 30 percent of its value relative to the US dollar. In the following seven years, from January 2012 to January 2019, the value of the Lira depreciated from 1.83 TL per US dollar to 5.47 TL per US dollar, a three-fold increase.

[37] According to figures compiled by the Turkish government, in 2019 there were approximately 3.7 million Syrian refugees living in Turkey. Across the six subsidy regions, Syrian refugees comprised 3.1 percent of the population in Region 1, 4.1 percent in Region 2, 6.5 percent in Region 3, 6.1 percent in Region 4, 4.3 percent in Region 5, and 6.3 percent in Region 6.

See `https://web.archive.org/web/20190903234802/https://www.goc.gov.tr/kurumlar/goc.gov.tr/Istatistikler/EYLUL/2EYLUL/24_gecici_koruma_kapsamindaki_suriyelilerin_illere_gore_dagilimi_07022019.jpg`. Accessed November 8, 2022.

References

Acar, A. and X. D. Carpio (2019): "Turkey Jobs Diagnostic," Tech. rep., World Bank.

Acemoglu, D., V. M. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi (2012): "The Network Origins of Aggregate Fluctuations," *Econometrica*, 80, 1977–2016.

Ackerberg, D. A., K. Caves, and G. Frazer (2015): "Identification Properties of Recent Production Function Estimators," *Econometrica*, 83, 2411–2451.

Algan, Y. and P. Cahuc (2014): " Trust, Growth, and Well-Being: New Evidence and Policy Implications," in *Handbook of Economic Growth*, ed. by J. V. Henderson and J. F. Thisse, Elsevier, vol. 2 of *Handbook of Economic Growth*, chap. 2, 49–120.

Angrist, J. D., G. W. Imbens, and D. B. Rubin (1996): "Identification of Causal Effects Using Instrumental Variables," *Journal of the American Statistical Association*, 91, 444–455.

Atalay, E., A. Hortaçsu, M. Runyun, C. Syverson, and M. F. Ulu (2023): "Micro- and Macroeconomic Impacts of a Place-Based Industrial Policy," Tech. Rep. 23-12, Federal Reserve Bank of Philadelphia.

Autor, D. H., D. Dorn, and G. H. Hanson (2013): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103, 2121–2168.

Barrot, J.-N. and J. Sauvagnat (2016): "Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks," *Quarterly Journal of Economics*, 131, 1543–1592.

Bernard, A. B., A. Moxnes, and Y. U. Saito (2019): "Production Networks, Geography, and Firm Performance," *Journal of Political Economy*, 127, 639–688.

Bernini, C. and G. Pellegrini (2011): "How Are Growth and Productivity in Private Firms Affected by Public Subsidy? Evidence from a Regional Policy," *Regional Science and Urban Economics*, 41, 253–265.

Bureau of Economic Analysis (2023): "Personal Income by County and Metropolitan Area," https://www.bea.gov/sites/default/files/2023-11/lapi1123msa.xlsx.

Busso, M., J. Gregory, and P. Kline (2013): "Assessing the Incidence and Efficiency of a Prominent Place Based Policy," *American Economic Review*, 103, 897–947.

Caliendo, L., M. Dvorkin, and F. Parro (2019): "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock," *Econometrica*, 87, 741–835.

Caliendo, L., L. D. Opromolla, F. Parro, and A. Sforza (2021): "Goods and Factor Market Integration: A Quantitative Assessment of EU Enlargement," *Journal of Political Economy*, 129, 3491–3545.

Cansiz, M. (2010): "Türkiye'de Organize Sanayi Bölgeleri Politikaları ve Uygulamaları," Tech. rep.

Carvalho, V. M., M. Nirei, Y. U. Saito, and A. Tahbaz-Salehi (2020): "Supply Chain Disruptions: Evidence from the Great East Japan Earthquake," *Quarterly Journal of Economics*, 136, 1255–1321.

Chaurey, R. (2017): "Location-Based Tax Incentives: Evidence from India," *Journal of Public Economics*, 156, 101–120.

Choi, J. and A. A. Levchenko (2024): "The Long-Term Effects of Industrial Policy," Tech. rep.

Combes, P.-P. and L. Gobillon (2015): "Chapter 5 - The Empirics of Agglomeration Economies," in *Handbook of Regional and Urban Economics*, ed. by G. Duranton, J. V. Henderson, and W. C. Strange, Elsevier, vol. 5 of *Handbook of Regional and Urban Economics*, 247–348.

Criscuolo, C., R. Martin, H. G. Overman, and J. V. Reenen (2019): "Some Causal Effects of an Industrial Policy," *American Economic Review*, 109, 48–85.

Demir, B., A. C. Fieler, D. Y. Xu, and K. K. Yang (2024a): "O-Ring Production Networks," *Journal of Political Economy*, 132, 200–247.

Demir, B., B. Joavorcik, T. K. Michalski, and E. Ors (2024b): "Financial Constraints and Propagation of Shocks in Production Networks," *Review of Economics and Statistics*, 106, 437–454.

Etzel, T., S. Siegloch, and N. Wehrhöfer (2021): "Direct, Spillover and Welfare Effects of Regional Firm Subsidies," Tech. rep.

Faber, B. and C. Gaubert (2019): "Tourism and Economic Development: Evidence from Mexico's Coastline," *American Economic Review*, 109, 2245–2293.

Fajgelbaum, P. and C. Gaubert (2020): "Optimal Spatial Policies, Geography, and Sorting," *Quarterly Journal of Economics*, 135, 959–1036.

Fernald, J. (2015): "Productivity and Potential Output Before, During, and After the Great Recession," *NBER Macroeconomics Annual*, 29, 1 – 51.

Foster, L., J. Haltiwanger, and C. Syverson (2008): "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" *American Economic Review*, 98, 394–425.

Gaubert, C., D. Yagan, and P. M. Kline (2021): "Place-Based Redistribution," Tech. rep.

Givord, P., R. Rathelot, and P. Sillard (2013): "Place-Based Tax Exemptions and Displacement Effects: An Evaluation of the Zones Franches Urbaines Program," *Regional Science and Urban Economics*, 43, 151–163.

Greenstone, M., R. Hornbeck, and E. Moretti (2010): "Identifying Agglomeration Spillovers: Evidence from Winners and Losers of Large Plant Openings," *Journal of Political Economy*, 118, 536–598.

Incoronato, L. and S. Lattanzio (2024): "Place-Based Industrial Policies and Local Agglomeration in the Long Run," Tech. rep.

Kaplan, G. and S. Schulhofer-Wohl (2012): "Interstate Migration Has Fallen Less Than You Think: Consequences of Hot Deck Imputation in the Current Population Survey," *Demography*, 49, 1061–1074.

Kim, M., M. Lee, and Y. Shin (2021): "The Plant-Level View of an Industrial Policy: The Korean Heavy Industry Drive of 1973," Tech. rep.

Kleinman, B., E. Liu, and S. J. Redding (2023): "Dynamic Spatial General Equilibrium," *Econometrica*, 91, 385–424.

Kline, P. and E. Moretti (2014): " Local Economic Development, Agglomeration Economies, and the Big Push: 100 Years of Evidence from the Tennessee Valley Authority," *Quarterly Journal of Economics*, 129, 275–331.

KPMG (2018): "Investment in Turkey: Tax Services," https://assets.kpmg/content/dam/kpmg/tr/pdf/2018/05/investment-in-turkey-2018.pdf.

LaPoint, C. and S. Sakabe (2022): "Place-Based Policies and the Geography of Corporate Investment," Tech. rep.

Liu, E. (2019): "Industrial Policies in Production Networks," *Quarterly Journal of Economics*, 134, 1883–1948.

Lu, Y., J. Wang, and L. Zhu (2019): "Place-Based Policies, Creation, and Agglomeration Economies: Evidence from China's Economic Zone Program," *American Economic Journal: Economic Policy*, 11, 325–360.

Milliyet (2022): "Korkunç Senaryo! İstanbul Çöküşe Doğru Gidiyor (Frightening Scenario! İstanbul is Heading Towards Collapse)," https://www.milliyet.com.tr/gundem/cozum-tersine-goc-6704377.

Monras, J. (2020): "Immigration and Wage Dynamics: Evidence from the Mexican Peso Crisis," *Journal of Political Economy*, 128, 3017–3089.

Neumark, D. and H. Simpson (2015): "Place-Based Policies," in *Handbook of Regional and Urban Economics*, ed. by G. Duranton, J. V. Henderson, and W. C. Strange, Elsevier, vol. 5B of *Handbook of Regional and Urban Economics*, 49–120.

Slattery, C. and O. Zidar (2020): "Evaluating State and Local Business Incentives," *Journal of Economic Perspectives*, 34, 90–118.

Sungur, O. (2019): "Spatial Distribution of Investment Incentives and the Impact of New Incentive System for Less Developed Regions in Turkey," *Review of Economic Perspectives*, 19, 25–48.

Tabellini, G. (2010): "Culture and Institutions: Economic Development in the Regions of Europe," *Journal of the European Economic Association*, 8, 677–716.

Timmer, M. P., E. Dietzenbacher, B. Los, R. Stehrer, and G. J. de Vries (2015): "An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production," *Review of International Economics*, 23, 575–605.

Timmer, M. P., B. Los, R. Stehrer, and G. J. de Vries (2016): "An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release," Tech. rep.

Turkish Statistical Institute (2022a): "Population of Provinces by Years," https://data.tuik.gov.tr/Bulten/Index?p=The-Results-of-Address-Based-Population-Registration-System-2020-37210&dil=2.

——— (2022b): "Provincial In-Migration, Out-Migration, Net Migration and Rate of Net Migration," https://data.tuik.gov.tr/Bulten/Index?p=International-Migration-Statistics-2018-30711.

——— (2023): "Gross Domestic Product per Capita by Provinces," https://data.tuik.gov.tr/Bulten/Index?p=Gross-Domestic-Product-by-Provinces-2022-45867.

Online Appendix—Not for Publication

A Data

In this section, we discuss our data sources and data cleaning procedures (Appendix A.1). In Appendix A.2, we then compare aggregates computed from our micro data sources to those in publicly available datasets. Much of the discrepancy between the two arises due to the lack of information on informal-economy workers in our micro datasets. Part of the discrepancy is due to limited coverage of our firm-level dataset in certain industries: Agriculture, Finance, Insurance, Real Estate, and Public Administration. In Appendix A.3, we compute the share of employment that is informal in each industry-region cell, then re-compare aggregates from our micro data sources to those in publicly available datasets. In the same appendix, we then describe how we account for the lack of micro data coverage in the Agriculture; Finance, Insurance, and Real Estate; and Public Administration sectors. Finally, in Appendix A.4 we discuss how we compute labor flows across industry-by-subsidy region pairs.

A.1 Details on Entrepreneur Information System (EIS)

The Entrepreneur Information System (EIS) is administered by the Ministry of Industry and Technology in Turkey. It compiles data from seven public institutions: the Ministry of Customs and Trade, Revenue Administration (GIB), the Social Security Institution (SGK), the Small and Medium Enterprises Development and Support Administration (KOSGEB), the Turkish Statistical Institute (TÜİK), the Turkish Patent Institute (TPI) and the Scientific and Technological Research Council of Turkey (TÜBİTAK). In this study, we use the following data sets from the EIS: the "Entrepreneurship Registry Microdata Set," the "Workplace Registry Microdata Set," and the "Balance Sheet Micro Dataset." While calculating the indirect effects and detailed employment effects, we also use the "Declaration-Buying/Selling (BA/BS) Micro Dataset" and the "Employee Micro Dataset." The EIS covers most Turkish manufacturing and service companies but excludes most of the finance, insurance, real estate, and agricultural sectors as well as public-sector personnel.

Table 14 lists the number of firms in our sample by year and industry. There are 212,458 unique firms in our sample, and 1,039,766 firm-year observations. At the beginning of the sample, approximately 69 percent of the firms in our sample are headquartered in Region 1; slightly less than 3 percent of the sample are from Region 6. The number of firms in the sample has grown by 5.8 percent per year, with faster growth in Regions 5 and 6 and slower growth in Region 1. By 2017 and 2018, near the end of the sample, 6 percent of the firms were headquartered in Region 6, 61 percent in Region 1.

From our sample, we exclude companies with missing, negative, or zero values for total assets, sales, long-term and tangible assets, short- and long-term liabilities, current assets, total

Table 14: Firm Counts

Year\Region	1	2	3	4	5	6	Total
2006	33,117	5,440	3,797	2,497	1,568	1,286	47,705
2007	36,150	6,177	4,467	3,192	1,966	1,687	53,639
2008	38,758	6,578	4,912	3,651	2,352	2,161	58,412
2009	36,147	6,457	4,978	3,687	2,440	2,314	56,023
2010	39,386	7,243	5,541	4,200	2,769	2,856	61,995
2011	43,780	8,167	6,324	4,743	3,101	3,206	69,321
2012	47,638	9,215	7,229	5,327	3,562	4,025	76,996
2013	50,962	9,582	7,538	5,266	3,525	4,082	80,955
2014	53,743	10,105	8,066	5,531	3,655	4,542	85,642
2015	57,538	11,223	8,801	5,968	3,967	4,684	92,181
2016	56,891	11,430	8,683	5,872	3,998	4,813	91,687
2017	57,954	11,793	9,155	6,028	4,205	5,300	94,435
2018	58,768	11,868	9,294	6,114	4,250	5,571	95,865
2019	50,674	9,040	6,919	2,450	2,083	3,576	74,910
Total	133,887	25,878	20,366	13,858	9,961	12,879	212,458

bank loans, payments, other liabilities, and long-term debts. In our firm-level regressions, we winsorize the top and bottom 0.5 percent of the firm-level distributions for revenues.

A.2 Auditing the Micro Data

In this section, we evaluate the coverage of the micro datasets listed in Appendix A.1. These firm and worker datasets measure activity only in the formal economy. The micro data additionally exclude most firms in the agriculture, finance, and public administration industries, as well as public firms in the education industry. The EIS data thus may miss a substantial fraction economic activity. Furthermore, the coverage of our micro data may vary with geography (with greater coverage in the larger cities and in the west) and industry (with greater coverage in the non-agricultural sectors of the economy). Our goal, for now, is to gauge the severity of these coverage issues. In Appendix A.3 and A.4, we describe how to impute the extent of informality by industry and subsidy region, then discuss how to account for informality when calibrating our Section 5 model.

We provide two sets of comparisons. In the first, we compare province-level employment in our micro data to its counterpart in aggregate datasets compiled by TürkStat (the Turkish Statistical Institute). In the second comparison, we compare industry-level output and factor shares according to our micro data to aggregate statistics derived from the Socio-Economic Accounts from the World Input-Output Database (WIOD).

In our first comparison, we aggregate the total employment among the firms in our micro data, summing across firms within (groups of) provinces. We compare this employment figure to the number of employed individuals measured in TürkStat. Figure 11 presents this comparison for a single year, in 2014. Because our dataset excludes informal-economy workers, it consistently

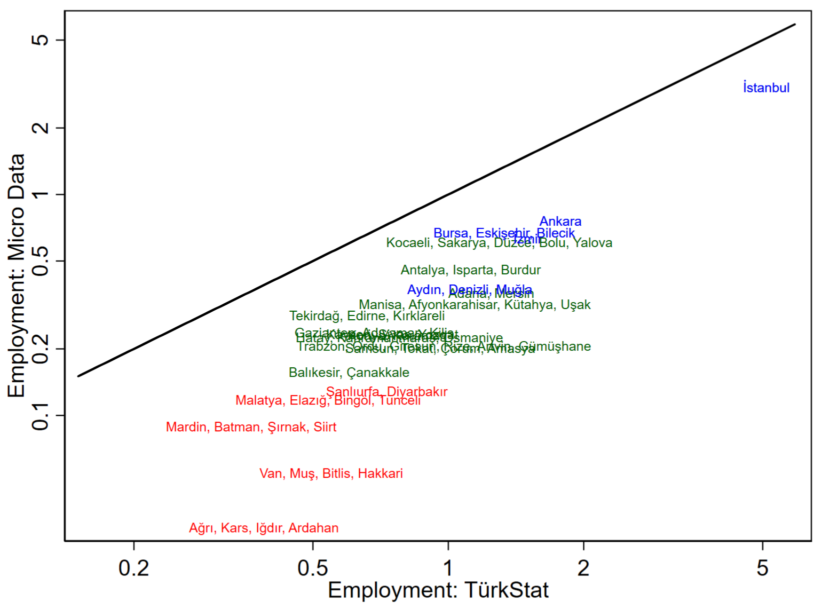

Figure 11: Comparison of Micro to Aggregate Data: Province Employment
Notes: The values on each axis are millions of workers. Groups of provinces overlapping with the least-heavily subsidized Region 1 are colored in blue; groups of provinces overlapping with the most-heavily subsidized Region 6 are colored in red. All other groups of provinces are colored in green.

reports fewer workers than the aggregate dataset. Furthermore, this relative discrepancy is smaller in the first subsidy region (e.g., Ankara; İstanbul; Bursa, Eskişehir, and Bilecik) than in the sixth subsidy region (e.g., Van, Muş, Bitlis, and Hakkâri; Ağrı, Kars, Iğdır, and Ardahan; and Mardin, Batman, Şırnak, and Siirt).

In our second comparison, we aggregate different output and input measures — total wage compensation, total employment, and total gross output — among the firms in our micro dataset. We use these aggregates to compute industries' total gross output, total employment, average wages per employee, and labor shares. Figure 12 compares these four industry-level measures to their corresponding values in the World Input-Output Database. In addition to the two datasets' disparate treatment of informal economy workers, the World Input-Output Database applies a different industry definition relative to that in our micro dataset. For this reason, low concurrence across the two datasets is less of a concern than in Figure 11. With this caveat in mind, the correlations depicted in the four panels of Figure 12 are 0.55 (for log gross output), 0.55 (for log employment), 0.10 (for average wages), and 0.13 (for the labor share.) The Spearman rank correlations are somewhat higher: 0.57, 0.64, 0.39, and 0.08, respectively. The biggest difference in terms of industries' size is in the agriculture sector: According to the WIOD, the gross output of the agricultural sector was 143.8 billion TL as of 2012. Of this, only 11.7 billion TL are recorded in our micro database. For other industries, the difference is less stark. Overall, there are considerable differences in the output measures across the two data sources.

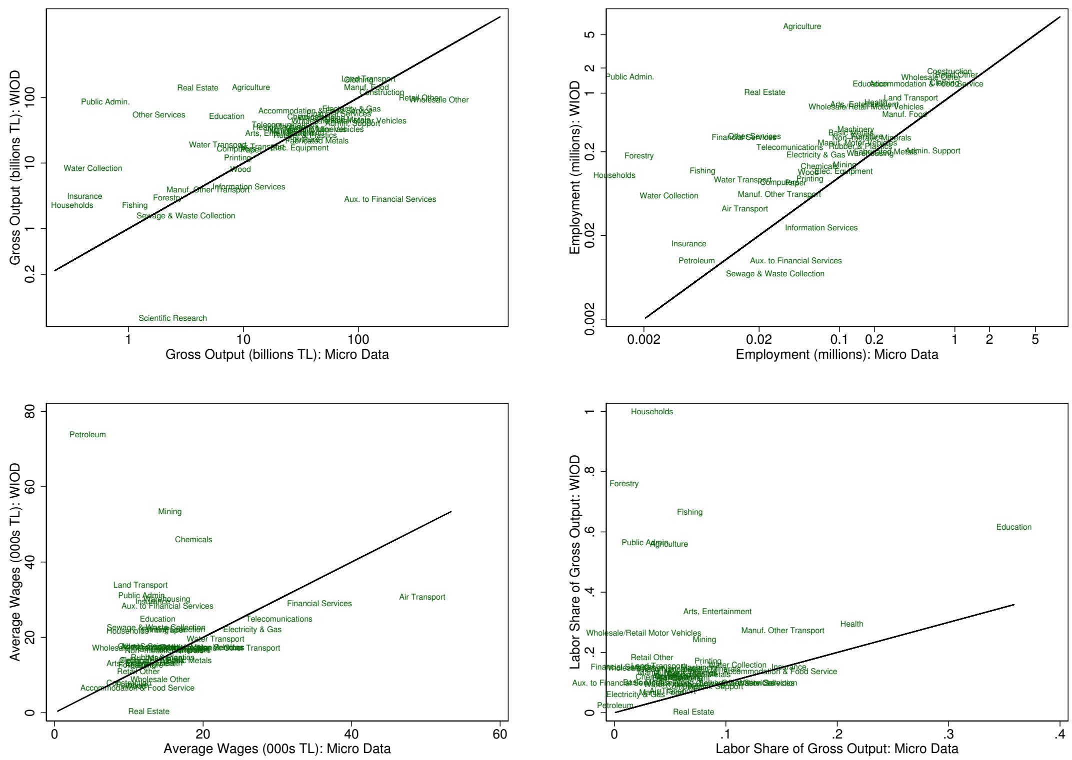

Figure 12: Comparison of Micro to Aggregate Data: Industry Activity in 2012
Notes: Values in the top left and bottom left panel are reported in 2010 Turkish Liras.

A.3 Accounting for Informality and Incomplete Data Coverage

In calibrating our aggregate model — in particular when calibrating output and employment by industry and subsidy region, and trade and migration flows across industry-region pairs — we require consistent measures of aggregate activity at the industry-region pair. (Widely available data sources, such as the WIOD, contain measures of economic activity at the industry-by-year level or the province-by-year level. The calibration of our Section 5 model requires information on the latter sets of moments, which we use our EIS data to calibrate.) In the previous subsection, we documented considerable discrepancies between aggregates computed using the EIS micro data and comparable aggregates from publicly available datasets. We hypothesized that part of this discrepancy was due to the fact that the EIS data captures only the formal economy. In addition, part relates to the lack of coverage in the EIS micro data in certain industries: Agriculture; Finance, Insurance, Real Estate; and Public Administration.

In this appendix, drawing on Acar and Carpio (2019), we explain how we estimate informality at the province-industry level. We then reproduce Figures 11 and 12, accounting for the lack of EIS data on the informal economy and, additionally, for incomplete coverage in the industries

Table 15: Formal Share by Sector

Sector	Formal Share
Agriculture, Forestry, Fishing	17.0%
Mining	96.0%
Manufacturing	83.5%
Services, Transport	73.0%
Construction	64.0%
Wholesale, Retail	72.0%
Accommodation, Food Service	69.0%
Other Services	82.0%

Notes: This table reproduces Figure 25 of Acar and Carpio (2019). Acar and Carpio (2019) provide two estimates of the formal share for manufacturing — 77 percent in low/medium-skilled manufacturing and 90 percent in high-skilled manufacturing — and two estimates of the formal share for services — 69 percent in low/medium-skilled services and 95 percent in high-skilled service. For each sector we take the average of these two numbers.

listed above. The end-result in this section is $\hat{\hat{\varphi}}_{pj,t}$, our estimate of the share of economic activity (in province p and industry j) that the EIS is able to capture.

Accounting for Informality

Acar and Carpio (2019) provide estimates of the share of employment that is formal — by broad sector and by groups of provinces — as of 2017. We reproduce these estimates in Tables 15 and 16. The formal share is lowest in Ağrı, Kars, Iğdır, and Ardahan (32 percent) and highest in Ankara (82 percent). Furthermore, the share of workers in the formal sector is lowest in Agriculture, Forestry and Fishing (17 percent) and highest in Mining (96 percent).

In addition, Acar and Carpio (2019) present trends in the national economy-wide formality rate. Let $\hat{\varphi}_{p,2017}$ refer to Acar and Carpio (2019)'s estimate of the formal share in 2017 in province p and $\hat{\varphi}_{j,2017}$ refer to the corresponding estimate of the formal share in industry j. Our goal is to impute the formal share in an arbitrary year, for each industry-province pair. Call this object $\hat{\varphi}_{pjt}$.

To compute $\hat{\varphi}_{pnt}$ we follow a two-step procedure. In a first step, using $\bar{\varphi}_t$ to denote the economy-wide formal share in year t, we initially set $\check{\varphi}_{pjt} = \hat{\varphi}_{j,2017} \cdot \frac{\bar{\varphi}_t}{\bar{\varphi}_{2017}} = \hat{\varphi}_{j,2017} \cdot \frac{\bar{\varphi}_t}{0.66}$. This initial variable, $\check{\varphi}_{pjt}$, allows us to match formal shares at the industry level, but does not capture any between-province variation. In a second step, using $\overline{\check{\varphi}}_{pjt}$ to refer to the economy-wide average of $\check{\varphi}_{pjt}$, we replace $\check{\varphi}_{pjt}$ with $\hat{\varphi}_{pjt} = \check{\varphi}_{pjt} \cdot \frac{\hat{\varphi}_{p,t}}{\overline{\check{\varphi}}_{pjt}}$. Figure 13 plots the formal employment share by industry and subsidy region. According to this figure, there is heterogeneity in both dimensions: within each region, formal employment shares are higher in mining and lower in agriculture; and within each industry, formal shares are higher in Region 1 and lower in Region 6.

We reproduce Figure 11 using Acar and Carpio (2019)'s estimates of informality by group

Table 16: Formal Share by NUTS-2 Region

NUTS-2 Region	Formal Share	NUTS-2 Region	Formal Share
İstanbul	79%	Nevşehir, Aksaray, Kırşehir, Niğde, Kırıkkale	62%
Edirne, Tekirdağ, Kırklareli	67%	Kayseri, Sivas, Yozgat	69%
Balıkesir, Çanakkale	61%	Zonguldak, Karabük, Bartın	56%
İzmir	76%	Kastamonu, Çankırı, Sinop	45%
Denizli, Aydın, Muğla	66%	Samsun, Tokat, Çorum, Amasya	55%
Manisa, Afyonkarahisar, Uşak, Kütahya	61%	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	49%
Bursa, Eskişehir, Bilecik	77%	Erzurum, Erzincan, Bayburt	52%
Kocaeli, Sakarya, Düzce, Bolu, Yalova	71%	Kars, Ağrı, Iğdır, Ardahan	32%
Ankara	82%	Malatya, Elâzığ, Bingöl, Tunceli	51%
Konya, Karaman	58%	Van, Muş, Bitilis, Hakkâri	37%
Antalya, Isparta, Burdur	68%	Adıyaman, Gaziantep, Kilis	61%
Adana, Mersin	60%	Diyarbakır, Şanlıurfa	38%
Hatay, Kahramanmaraş, Osmaniye	58%	Siirt, Mardin, Batman, Şırnak	60%

Notes: This table reproduces Figure 24 of Acar and Carpio (2019).

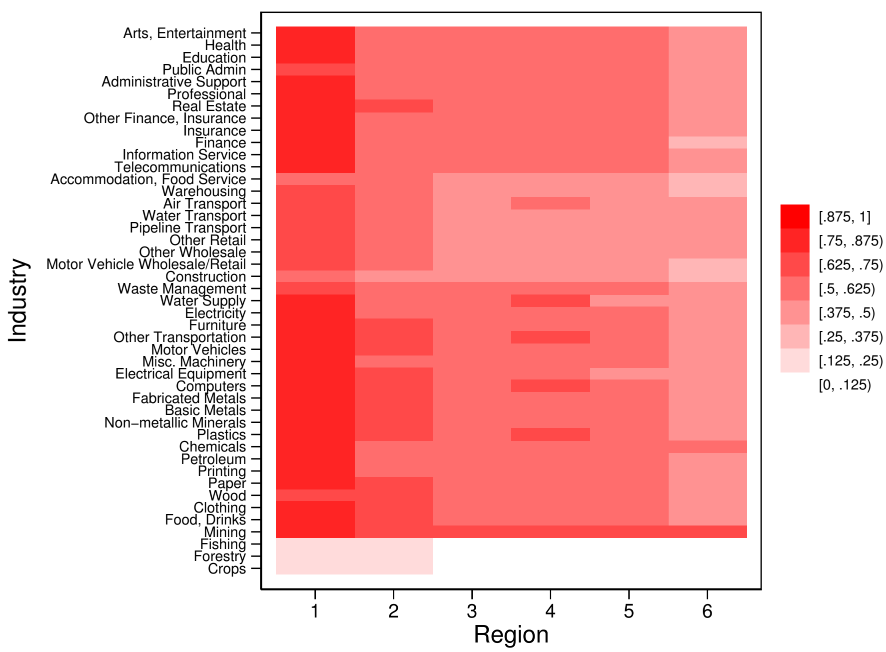

Figure 13: Formal Employment Share by Industry and Region

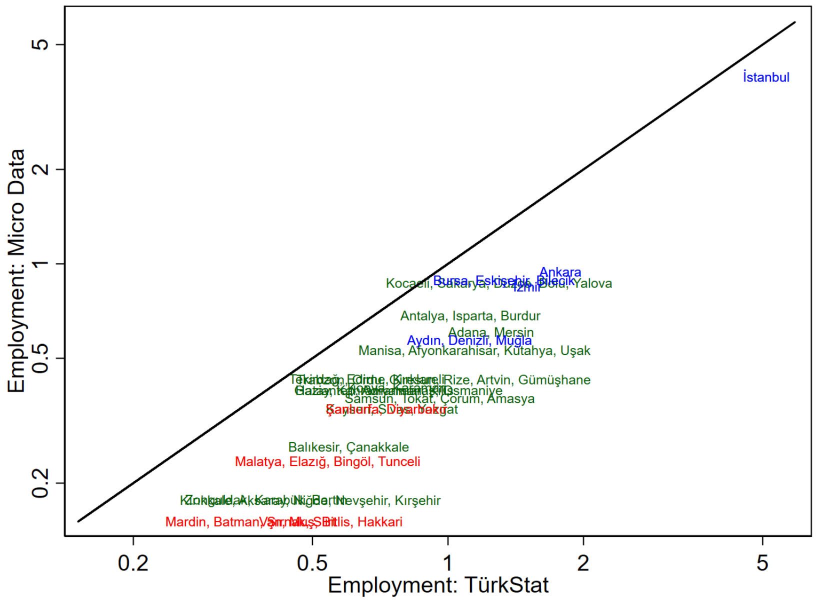

Figure 14: Comparison of Micro to Aggregate Data: Employment by NUTS-2 Geography
Notes: See the notes for Figure 11. In contrast to that figure, we adjust the micro data to account for differences in the share of informality across groups of provinces.

of provinces. For each group of provinces, we divide our measure of the micro data employment by $(1 - \hat{\varphi}_{p,2014}) = \left(1 - \hat{\varphi}_{p,2017} \cdot \frac{0.65}{0.66}\right)$, where the $\frac{0.65}{0.66}$ accounts for the fact that formal share increased by 1 percentage point, from 0.65 to 0.66, between 2014 and 2017.

We plot the informality-adjusted measure of employment in the EIS micro data against employment in the TürkStat data. When adjusted for differences in the share of formal workers by groups of provinces, the discrepancy between the two measures of employment is substantially smaller in Figure 14 than in Figure 11.

Accounting for Limited Data in Certain Industries

In addition to informality, the EIS data sample frame spans covers certain industries. The EIS aims to measure economic activity in the private sector, excluding as well firms in the Agriculture industry and in the Finance, Insurance, and Real Estate ("F.I.R.E.") sector. In practice, the dataset resulting from the EIS surveys includes a fraction of firms in these industries. Unfortunately, we lack systematic evidence on the extent to which the EIS dataset under-represents formal-sector firms in these industries. One guide comes in the top two panels of Figure 12: There, we see that the EIS data severely under-represent activity in the Public Administration industry, and substantially (but not quite as severely) under-represent activity in the Agriculture and F.I.R.E. industries. (To be clear, part of these discrepancies are due to the lack of coverage of the informal economy.) We assume that the EIS data cover 25 percent of formal-sector activity in the Public Administration industry, 40 percent of activity in the

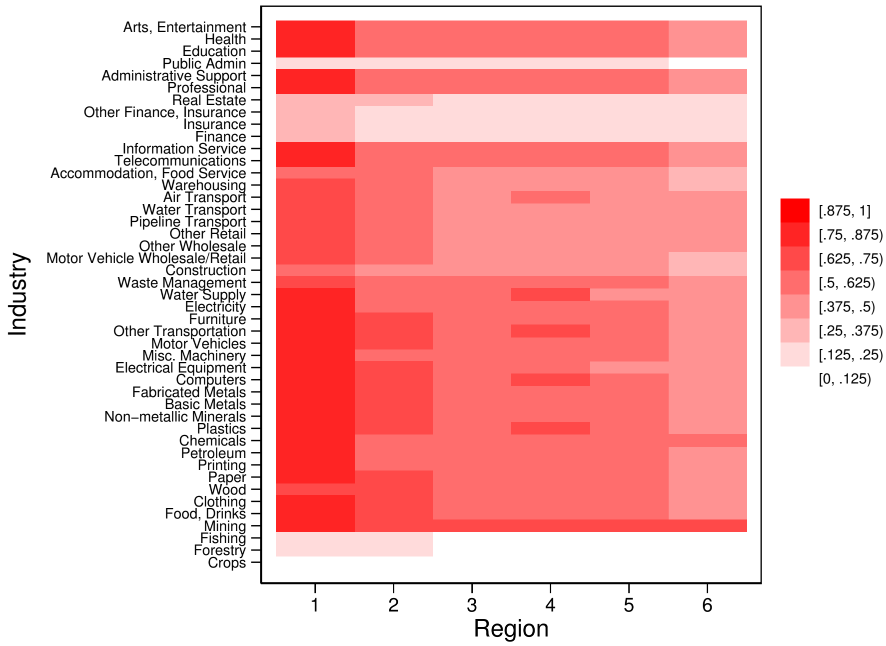

Figure 15: Share of Activity Represented In EIS Data

Agriculture industry, and 40 percent of activity in F.I.R.E. industries. (In unreported exercises, we experiment with alternate assumptions. Our assessment of the regional inequality impacts of the policy are robust to reasonable alternate choices.) Letting $\hat{\hat{\varphi}}_{pjt}$ denote the share of economic activity in province p and industry j that is covered in year t by the micro EIS dataset, we thus set:

$$\begin{aligned}
\hat{\hat{\varphi}}_{pj,t} &= \hat{\varphi}_{pjt} \cdot 0.25, \text{ for j=Public Administration;} \\
&= \hat{\varphi}_{pjt} \cdot 0.40, \text{ for j=Agriculture, Finance, Insurance,} \\
&\qquad\qquad \text{Other Finance and Insurance, Real Estate; and} \\
&= \hat{\varphi}_{pjt} \cdot 1.00, \text{ for all other industries.}
\end{aligned}$$

Auditing the Micro Data after Adjusting for Informality and Missing Data

Figure 15 presents our estimates of $\hat{\hat{\varphi}}_{pjt}$ for t =2012. Except for Agriculture, F.I.R.E. and Public Administration, the values in Figure 15 match those in Figure 13. For these 40 industries, $\hat{\hat{\varphi}}_{pjt} < 1$ only because a share of the firms within these industries are informal. For the remaining five industries, $\hat{\hat{\varphi}}_{pjt} < \hat{\varphi}_{pjt}$.

Figure 16 now compares sales and employment, according to the WIOD and the EIS. In contrast to Figure 12, our EIS measures are scaled up by $1/\hat{\hat{\varphi}}_{\cdot,j,2012}$ (that is, $\hat{\hat{\varphi}}_{pj,2012}$ as averaged across provinces, p). Overall, the two sales and employment measures are more aligned with one another with this adjustment. The (WIOD-sales-weighted) correlation of log sales in the

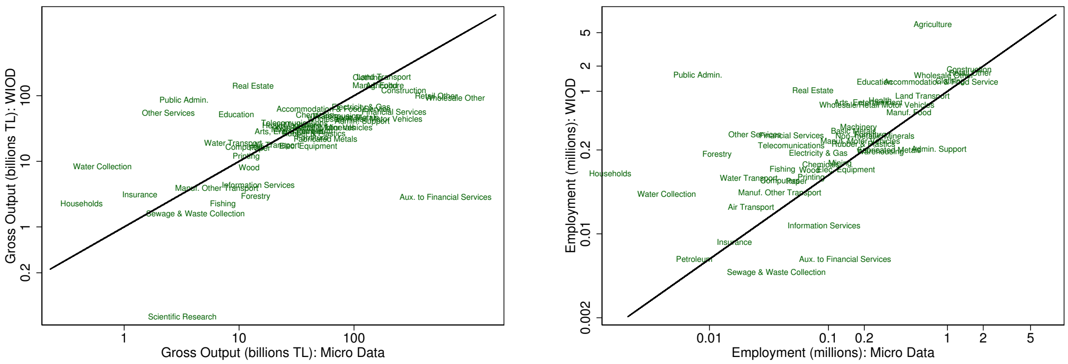

Figure 16: Comparison of Micro to Aggregate Data: Industry Activity in 2012
Notes: Values in the top left and bottom left panel are reported in 2010 Turkish Liras.

two data sources is 0.45 (compared to 0.30 absent any adjustments). The (WIOD-employment-weighted) correlation of log employment in the two data sources is 0.49 (compared to 0.26 absent any adjustments).

In sum, the EIS sample frame does not span the entire economy. First, the EIS sample excludes firms in the informal economy. In addition, for firms in certain industries, the EIS dataset does not measure activity even for all formal-economy firms. Accounting for these differences in the extent to which the EIS dataset misses activity within firms in individual province-industry pairs, the EIS data align reasonably well with existing estimates of industries' (or geographies') employment and gross output.

A.4 Imputing Employment Flows

In this section we discuss the construction of Figure 3. This figure describes flows of workers across subsidy region-industry cells across subsequent years. In computing these flows, we face two challenges. First, our micro data do not record transitions into or out of non-employment. (The data track individuals across time, permitting measurement of entry to and exit from firms within our dataset. However, since the dataset does not cover informal-sector firms, and additionally misses most firms in Agriculture, Finance, Insurance, Real Estate, and Public Administration industries, this dataset does not allow one to distinguish whether an individual is not employed, employed in an informal-sector industry, or employed in a firm missed by our dataset.) Second, to maintain confidentiality, we were permitted by the Ministry of Industry and Technology to disclose flows of workers in slightly aggregated industries.[38] Below, let j denote

[38]When disclosing the data, we were asked to aggregate crops (NACE A01), forestry (NACE A02), finishing (NACE A03), and Mining (NACE B) into one sector; food, beverage, and tobacco manufacturing (NACE C10-C12) and textile, apparel, and leather manufacturing (C13-C15) into a second sector; and all other manufacturing (NACE C16-C33) into a third sector. We group electricity, gas, steam, and air conditioning (NACE E) and construction (NACE F) into a fourth sector; wholesale and retail (NACE G) into a fifth

one of the 45 industries in our baseline sample, and $\tilde{j}$ one of the more aggregated 13 sectors. Let $j = 0$ or $\tilde{j}$=0 denote non-employment. Our goal is to compute transition probabilities, $\mu^{nj,ik}$, giving the share of individuals who transition from industry-region pair nj to industry-region pair ik across two subsequent years. Below, we use $\mathfrak{m}^{n\widetilde{j},i\widetilde{k}}$ to denote the raw data on transitions among broad-sector-by-region pairs.

In a first step, we compute the vector of the share of workers in each region-industry (n-j) pair. From Eurostat (2021a, b), we retrieve employment-to-population ratios and population (among individuals who are 25 to 64 years old) by NUTS-2 region. We aggregate NUTS-2 regions' employment-to-population ratios up to our 6-subsidy-region categorization, weighting NUTS-2 regions by population. This yields an expression for the employment-to-population by year and subsidy region. Call this object $\bar{l}_{nt}$. From the EIS, we observe the share of formal-sector national employment in region n and industry j . Call this object l_{njt}. To compute the share of total employment in region n and industry j, we divide l_{njt} by $\hat{\hat{\varphi}}_{pj,t}$ (the share of subsidy region n and industry j activity that is captured by the EIS data; see Appendix A.3.) Call the resulting object $\widehat{l}_{njt}$. Given this, we can compute the share of the adult population belonging to region-industry pair n-j as

$$\begin{aligned} \widetilde{l}_{njt} &= \bar{l}_{nt} && \text{for } j = 0, \text{ and} \\ &= \left(1 - \bar{l}_{nt}\right) \hat{\hat{\varphi}}_{pj,t} && \text{for } j = \{1, ...J\}. \end{aligned}$$

In a second step, we account for the fact that our measures on flows of individuals across sectors and regions omit workers in firms that are not covered in our dataset. We scale up $\mathfrak{m}^{n\widetilde{j},i\widetilde{k}}$ by $\hat{\hat{\varphi}}_{n\widetilde{j}t}$ where $\widetilde{j}$ is the broad sector corresponding to industry j: ${\mu_t}^{n\widetilde{j},i\widetilde{k}} \equiv \mathfrak{m}^{n\widetilde{j},i\widetilde{k}} / \hat{\hat{\varphi}}_{n\widetilde{j}t}$.

In a third step, we combine information on $\widetilde{l}_{njt}$ and information on flows of formal-sector workers across region-broad-sector pairs to form our estimates of ${\mu_t}^{nj,ik}$. We consider three cases: whether (i) $n = i$ and $j = k$; whether (ii) $n = i$ and $j \neq k$, but industries j and k belong to the same broad sector; or (iii) all other cases (either $n \neq i$, or j and k belong to different broad sectors). In case (iii), we define ${\mu_t}^{nj,ik} \propto \widetilde{l}_{ikt}{\mu_t}^{n\widetilde{j},i\widetilde{k}}$ where $\sum_{k \in \widetilde{k}} {\mu_t}^{nj,ik} = {\mu_t}^{n\widetilde{j},i\widetilde{k}}$. That is, within each destination sector, the probability of transitioning to a particular industry is proportional to its employment share. We could have potentially applied this same definition for cases (i) and (ii), as well. However, this would have led us to miss a key feature of transition probabilities documented elsewhere, namely that individuals are substantially more likely to stay within the same industry-region pair across subsequent years. For case (ii), we set ${\mu_t}^{nj,ik}$ as the 75[th] percentile among the ${\mu_t}^{nj,i'k'}$ for which $i' = n$ and $\widetilde{j} \neq \widetilde{k}$. This definition allows for

sector; transportation and storage (NACE H) into a sixth sector; accommodation (NACE I) into a seventh sector; information and communication (NACE J) into an eighth sector; finance, insurance, and real estate (NACE K and NACE L) into a ninth sector; professional, scientific, and technical activities (NACE M) and administrative and support service activities (NACE N) into a tenth sector; public administration (NACE O) into an eleventh sector; education (NACE P) into a twelfth sector; and human health and social work (NACE Q), arts, entertainment, and recreation (NACE R), and other services (NACE S) into a thirteenth sector.

Table 17: Worker Flows Within and Across Industry-Region Pairs

Type of Flow	N	Mean	Percentile 25	50	75	90
Same Industry, Same Region ($i = n, j = k$)	276	0.5840	0.4409	0.6158	0.6813	0.6981
Different Industry, Same Region ($i = n, j \neq k$)	12,420	0.0089	0.0005	0.0019	0.0055	0.0169
Same Industry, Different Region ($i \neq n, j = k$)	1,380	0.0005	0.0000	0.0001	0.0006	0.0014
Different Industry, Different Region ($i \neq n, j \neq k$)	62,100	0.0001	0.0000	0.0000	0.0000	0.0001

relatively high values for within-industry, within-broad-sector flows. For case (i), we set ${\mu_t}^{nj,ik}$ as the residual probability.

In a fourth step, we ensure that our μs are consistent with aggregate domestic migration data. The EIS data track individuals across industries and subsidy regions. In principle, these flows broadly align with aggregate migration flows in publicly available data. But, due to the incomplete coverage in the EIS data, there are some modest discrepancies between the two data sources. We compute the number of working-age domestic migrants using data from from Turkish Statistical Institute (2022c). This dataset provides the number of migrants across province-pairs. Since we seek to track the number of migrants of individuals who are working age, we multiply these migrant flows by the share of the population that is between 25 to 64, using data from Turkish Statistical Institute (2022a). We sum up across the provinces within each origin and destination subsidy region, resulting in $\mathfrak{m}_{ni,t}$, the share of working-age region i individuals who migrate to region n in year t. We re-scale our flows of individuals across sectors and regions using $\mathfrak{m}_{ni,t}$ so that — for each source and destination region, n, i — the average (across source industries j) of ${\mu_t}^{nj,ik}$ equals $\mathfrak{m}_{ni,t}$.

Table 17 summarizes transition probabilities for 2012. The takeaway from this table is that flows are considerably higher when $i = n$ and $j = k$, somewhat lower when either $i = n$ or $j = k$, and lower still when neither $i = n$ nor $j = k$. Approximately 58.4 percent of individuals stay in their same industry-subsidy region pair across years; 40.0 percent($\approx 0.0089 \cdot \frac{12{,}420}{276}$) switch industries but not regions; and 1.6 percent switch subsidy regions.[39]

B Additional Detail Regarding Law 2012/3305

This appendix provides additional detail on the 2012 subsidy program.

[39] Flows into and out of non-employment (which is one of our "industries") constitute most of the between-industry flows. Excluding these, the share of workers switching industries from one year to the next is approximately 19 percent.

B.1 Subsidized Industries

According to the 2012 subsidy program, only projects within certain industries are eligible. The Turkish government lists subsidized industries at: `https://web.archive.org/web/20210603084940/resmigazete.gov.tr/eskiler/2012/06/20120619-1-2.xls` . The column labeled "US-97 Kodu," within the "2A_Sektörler" worksheet refers to the NACE 1.1 code. The second worksheet, labeled "2B_Iller," provides a mapping between provinces and subsidized industries. In this section, we translate and summarize the key elements of these two Excel worksheets.

Table 18: Mapping Between Turkish Government Industries and NACE Industries

Sector	NACE 2 Industries	Sector	NACE 2 Industries
1	1.41, 1.42, 1.43, 1.44, 1.45, 1.47	26	23
2	3.22	27	24.54
3	10	28	25
4	13	29	25
5	14	30	28
6	15	31	23
7	15.11	32	28.23
8	15.12, 15.20	33	26, 27
9	16	34	26.30
10	17	35	32.50
11	20	36	29
12	20.15	37	33.16
13	20.20	38	30.91, 30.92
14	21.20	39	31, 32.20, 32.30, 32.40, 32.99, 33.20
15	20.42	40	31.09
16	20.51	41	55.10, 55.20, 55.90
17	22.11	42	55.90
18	23	43	52.10
19	23	44	55.10
20	23	45	85
21	23	46	86.10, 86.20, 86.90, 87.20, 87.30, 87.90
22	23	47	
23	23	48	
24	23	49	
25	23	50	

In Table 18, we provide a mapping between the Turkish government's numbering of subsidized sectors and NACE (version 2) industry codes.

In Table 19, we provide a list of subsidized industries and Turkish provinces. To preserve space, we provide the correspondence only for the first ten provinces (listed alphabetically). For the entire correspondence, see the second worksheet of https://web.archive.org/web/20210603084940/resmigazete.gov.tr/eskiler/2012/06/20120619-1-2.xls .

Table 19: Lists of Subsidized Industries By Province

Code	Province	List of Subsidized Industries
1	Adana	1, 2, 3, 4, 8, 9, 10, 11, 20, 27, 28, 30, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43, 44, 45, 46, 47, 48, 50
2	Adıyaman	1, 2, 3, 4, 5, 8, 9, 10, 11, 18, 27, 28, 30, 32, 33, 34, 35, 36, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50
3	Afyonkarahisar	1, 2, 3, 4, 5, 9, 10, 14, 20, 27, 28, 30, 32, 33, 34, 35, 36, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50
4	Ağrı	1 through 50
68	Aksaray	1, 2, 3, 4, 5, 9, 10, 11, 26, 27, 28, 30, 32, 33, 34, 35, 36, 40, 41, 42, 43, 44, 45, 46, 48, 50
5	Amasya	1, 2, 3, 4, 5, 8, 9, 10, 14, 20, 27, 28, 30, 32, 33, 34, 35, 36, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50
6	Ankara	1, 2, 3, 4, 8, 9, 10, 14, 22, 27, 30, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43, 44, 45, 46, 48, 50
7	Antalya	1, 2, 3, 9, 10, 13, 14, 15, 24, 27, 30, 32, 33, 34, 35, 37, 39, 41, 42, 43, 44, 45, 46, 48, 50
75	Ardahan	1 through 50
8	Artvin	1, 2, 3, 4, 5, 8, 9, 10, 14, 25, 27, 28, 30, 32, 33, 34, 35, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50

Notes: This table provides the correspondence between provinces and subsidized industries. For the correspondence between these 50 industries and NACE 2 codes see Table 18.

B.2 Components of the Subsidy Scheme

The Regional Investment Subsidy elements vary across regions, and entail eight different support elements. Among these, the VAT exemption, customs tax exemption, corporate tax credit, insurance premium employer share support, and interest expense support are granted to all complying investments to varying degrees across regions, while income tax withholding support and employee's social security premium support are provided only in the sixth region. The distribution of subsidy elements by regions is shown in Table 21.

The most important support elements in Law 2012/3305 are the investment tax credits (ITC) and social security insurance premium supports. We explain how the investment tax credits translate to reduced corporate taxes with the following example: Consider ABC Company, which operates in Region 4 and plans to make an investment of 2,000,000 TL. With a 30 percent ITC rate, the total tax credit is 600,000 (=2,000,000×0.3) TL. Also, suppose that the annual corporate tax base for this firm is 500,000 TL, which would normally imply 110,000 TL in corporate taxes that it would pay each year. Given the 70 percent deduction rate, the

Table 21: Support Elements of the Regional Investment Subsidy Programs

			Regions					
Suppeort Elements			1	2	3	4	5	6
VAT Exemption			✓	✓	✓	✓	✓	✓
Customs Duty Exemption			✓	✓	✓	✓	✓	✓
Corporate Tax Deductions	Investment tax Credit Rate (ITC)	Non-OIZ	15	20	25	30	40	50
		OIZ	20	25	30	40	50	55
	Deduction Rate		50	55	60	70	80	90
Employer's National Insurance Contribution Support (Years)			2	3	5	6	7	10
Interest Expense Support	TL Loan		No	No	3pp	4pp	5pp	7pp
	FX Loan				1pp	1pp	2pp	2pp
	Cap (,000 TL)				500	600	700	900
Employee's National Insurance Contribution Support			No	No	No	No	No	10 years
Income Tax Withholding Support			No	No	No	No	No	10 years

Notes: OIZ refers to an Organized Industrial Zone.

company pays 30 percent of its tax debt in its first year with a closed subsidy certificate. This amounts to 33,000 TL. With 77,000 TL of taxes deducted in the first year, ABC Company has 523,000 TL which it can deduct in future years. If the company were to have the same real income and tax levels, the company would deplete its tax credit in approximately 8 years.

B.3 Subsidy Expenditures

In this appendix, we provide estimates on government outlays of two of the main components of the Turkish subsidy program: those related to investment tax credits and those related to employment.[40]

Table 22 presents our estimates of Turkish government expenditures via investment tax credits. To compute this table, we first multiply the total fixed investment with the investment tax credit rate that each firm receives. We then sum across firms in each subsidy region for subsidy documents opened in each year. According to this table, expenditures on investment tax credits were 2.6 billion TL in 2012, increasing to 6.9 billion in 2019. Overall, investment tax credits were evenly distributed across the six subsidy regions. Regions 1 and 2 had the most firms and economic activity, but lower subsidization rates. Regions 5 and 6 had fewer firms (and, for Region 6, an even smaller share of firms in eligible industries) but greater subsidization rates.

Table 23 reports expenditures on employment subsidies. Translating the number of years (call this yrs_r) of social security support — the variable indicating the level of employment subsidy generosity in each region — to government expenditures requires a simple calcula-

[40]Government expenditures on customs duties rebates and interest rate support represent a much smaller share of the total expenditures related to the 2012 subsidy program.

Table 22: Expenditures on Investment Tax Credits

	2012	2013	2014	2015	2016	2017	2018	2019	Total
Region 1	219	396	312	194	243	1,128	1,517	1,539	5,550
Region 2	255	864	471	1011	414	772	1,410	1,327	6,523
Region 3	565	758	654	499	499	966	1,408	1,276	6,625
Region 4	311	511	467	478	379	924	765	998	4,834
Region 5	644	721	382	545	483	794	926	651	5,146
Region 6	595	1224	540	561	424	989	850	1,120	6,303
Total	2,590	4,473	2,827	3,289	2,442	5,573	6,877	6,910	34,982

Notes: Values are millions of 2010 TL.

tion.[41] In contrast to Table 22, Region 6 received the greatest share of employment subsidies. This reflects both the increased statutory generosity — not only employer-mandated but also employee-mandated social security payments are subsidized in this region — and the fact that mandated social security payments are tied to the *national* minimum wage (which has an outsized effect in the low-wage Region 6).

Combining the two subsidy items and summing over 2012 to 2019, the national government spent approximately 55.1 billion TL on investment tax credits and reduced social security payments, with approximately 64 percent of these subsidies taking the form of investment tax credits. Annual expenditures more than doubled over the 2012 to 2019 period, going from 4.1 billion TL to 10.4 billion TL. Over the period, the regional composition of subsidy expenditures shifted from the high-subsidy to low-subsidy regions. Regions 5 and 6 received 51.4 percent of national government outlays in 2012 and 37.9 percent in 2019, while Region 1 received 9.3 percent in 2012 and 17.5 percent in 2019.

C Production Function Estimates

In this section, we present our production function estimates.

For each 2-digit NACE industry in our sample, we estimate a value-added production function, with labor and capital stocks as the two inputs. We use the firm's wage-bill as the measure of labor inputs and the real value of the capital stock (computed from annual data on capital

[41] Mandated social security payments are paid both by the employer and by the employee. Those paid by the employer are equal to 15.5 percent of the national minimum wage, while those paid by the employee are 19 percent of the national minimum wage. Subsidized firms in all regions receive support for the employer-mandated payment, while those projects in Region 6 additionally receive support for the employee contribution. For each firm (with employment e_f) headquartered in Regions 1 through 5, we compute the employment subsidies received as $sub_f = e_f \cdot 0.155 \cdot mw_t \cdot \frac{1.05^{yrs_r}-1}{0.05}$. For firms in Region 6, we compute the subsidy received as $sub_f = e_f \cdot (0.155 + 0.19) \cdot mw_t \cdot \frac{1.05^{yrs_r}-1}{0.05}$. In other words, we compute the present-discounted subsidies (discounting at a rate of 5 percent per year over the years over which the subsidies will be received) in proportion to the firm's employment and the national minimum wage at the time at which the subsidy was received. To compute the total subsidies received within each region and year, we sum sub_f across all firms who received a subsidy that year.

Table 23: Expenditures on Employment Subsidies

	2012	2013	2014	2015	2016	2017	2018	2019	Total
Region 1	163	227	305	159	131	349	341	285	1,960
Region 2	107	225	156	173	113	223	233	224	1,455
Region 3	234	253	288	170	145	226	272	208	1,798
Region 4	150	268	153	135	149	332	591	607	2,385
Region 5	260	484	385	268	281	541	606	481	3,307
Region 6	618	1,307	733	800	871	1,462	1,675	1,706	9,171
Total	1,532	2,765	2,020	1,705	1,691	3,133	3,719	3,510	20,076

Notes: Values are millions of 2010 TL.

investment expenditures), using a perpetual inventory method, as the measure of the capital input. We estimate the parameters of industries' production functions using the method introduced by Ackerberg et al. (2015), implementing the STATA command developed by Rovigatti and Mollisi (2016) . We assume that labor is free to vary intra-period, use the lag of investment and intermediate input purchases as proxy variables.[42]

To estimate productivity, we require measures of firms' real capital stocks. Unfortunately, because of sizable inflation rates before our sample, the reported book values of capital that exist within the EIS dataset are not reliable. Instead, we compute capital stocks using a perpetual inventory method type procedure. We follow, as closely as possible, the methods outlined in the OECD Manual of Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services.[43] We define firms' real capital stocks iteratively:

$$K_{f,t+1} = K_{ut} \cdot (1-\delta) + \frac{\Delta PPE_{f,t}}{P_t},$$

where $\Delta PPE_{f,t}/P_t$ is the real investment by firm t, and δ is the depreciation rate (which we set to 0.0.83). To apply this equation, we need to compute the initial-period capital stocks. Assuming that firms are near a balanced growth path (whereby investment is growing by 4 percent per year) in their first few years of the sample, we can compute the initial-period capital stocks based on the average investment levels in the first few years of the sample:

$$\begin{aligned} K_{f,2006} &= \sum_{\tau=-\infty}^{2005} \frac{\Delta PPE_{f,\tau}}{P_\tau} \cdot (1-\delta)^{2006-\tau} \\ &= \sum_{\tau=-\infty}^{2005} \frac{\overline{\Delta PPE_f}}{P} \cdot (1-0.04)^{2006-\tau} \cdot (1-\delta)^{2006-\tau} \\ &= \frac{\overline{\Delta PPE_f}}{P} \cdot \frac{1}{1-(1-0.04)(1-\delta)}, \end{aligned}$$

[42] While we do not present estimated production function parameters under alternate methodological choices, we show in Section D.2 that the impact of subsidization on firm productivity is robust to varying the set of proxy variables or simply to defining productivity as value added per worker.

[43] See `https://www.oecd.org/sdd/na/1876369.pdf`.

where $\frac{\overline{\Delta PPE_f}}{P}$ equals the average real investment in the first five years of the sample. (The second equation follows from the first under the assumption that pre-2006 investment equals a 4-percent deflated average of investment in the first five years of the sample.)

With measures of real capital stocks in hand, we are able to estimate real value added production functions. Table 24 presents our estimated production function parameters for the ten industries with the greatest number of observations. (Estimates for the other 76 industries are available on request.) For the median 2-digit industry in our sample, the sum of the coefficients on capital and labor equals 1.06, consistent with slightly increasing returns to scale. The coefficient on capital is approximately one-tenth of that of labor.

Table 24: Production Function Estimates

	Wage-Bill		Capital			
Industry	$\hat{\beta}$	S.E	$\hat{\beta}$	S.E	Count	Firms
10	0.860	(0.000)	0.205	(0.000)	33,747	5,919
13	0.926	(0.000)	0.116	(0.000)	33,631	5,924
14	0.930	(0.000)	0.100	(0.000)	45,881	10,007
25	0.911	(0.000)	0.143	(0.000)	28,763	6,042
41	0.927	(0.000)	0.0802	(0.002)	70,475	25,968
46	0.954	(0.000)	0.145	(0.000)	93,885	23,515
47	0.847	(0.000)	0.148	(0.000)	69,791	17,030
49	0.933	(0.000)	0.091	(0.000)	31,156	7,778
56	0.942	(0.000)	0.083	(0.000)	38,679	9,773
85	1.003	(0.001)	0.055	(0.005)	26,172	5,949

D Sensitivity Analysis Related to Sections 4 and 5

In this section, we collect sensitivity analyses and ancillary plots, complementing the material in Sections 4 and 5.

D.1 Sensitivity Analysis Related to Section 4.2

This section considers the sensitivity of the relationship between industry-province level subsidization and economic activity. To preview, under most but not quite all of these sensitivity analyses, we continue to find that greater and more generous subsidies lead to increased economic activity.

In Table 5 we analyzed the relationship between revenues, employment, capital stocks, and subsidization at the industry-province level. There, we weighted observations according to the average number of firms in the industry-province pair over the sample. In Table 24, we re-estimate Equation 1, weighting observations equally. Overall, while there are exceptions (in particular, column 2), estimates of the relationship between subsidization and revenues are somewhat larger than in the unweighted specifications. Yet, as in Table 5, the relationship is positive and statistically significant in most specifications. For employment, the OLS specifications are all positive and significant, with magnitudes comparable to those in Table 5. In the IV specifications, the relationship between employment is negatively related to subsidization without the inclusion of industry×year fixed effects. For plant, property, and equipment capital, the coefficients are uniformly positive, though statistically insignificant in two of the IV specifications.

In Table 25, we consider the impact of additional explanatory variables. In the first four columns — and in columns (7) through (10) — we consider the impact of accounting for the large and geographically heterogeneous inflow of Syrian refugees during the sample period. We control for the share of the population in the province that are Syrian refugees. We find that our estimated relationship between subsidization and revues are robust to these additional controls. In columns (5), (6), (11), and (12) we estimate a regression with an even-more comprehensive set of controls, with province-by-year fixed effects. While the coefficient estimates on the subsidization measures are somewhat smaller, their sign and significance matches with what was observed in Table 5. Our coefficient estimates are somewhat smaller than their corresponding estimates from Table 5.

Table 26 relates firm counts to subsidization. This relationship between the two variables is positive and significant in all six of the OLS specifications and three of the six IV specifications.

D.2 Sensitivity Analysis Related to Sections 4.3 and 4.4

Additional Outcome Variables

In this section, we consider additional estimations of Equation 3 with two alternate dependent variables: (i) the wage-bill and (ii) the wage-bill per employee. Columns (1) through (3) and (7) through (9) of Table 27 consider a second measure of labor inputs: the firms' wage-bill. The coefficient estimates are essentially equal to those given in Table 6, in which we compared firms' employment to subsidization rates. In columns (4) through (6) and (10) through (12), we relate the wages paid per employee and the investment tax credit rate that firms receive. The OLS specifications yield a precisely estimated null relationship between the two variables. The IV estimates are negative in certain specifications (those with industry-by-year fixed effects) and positive (but insignificant) estimates in others.[44] Our main takeaway from Table 27 is that greater subsidies do not lead firms to pay their workers higher wages. This conclusion accords with the results from our aggregate exercise in Section 5, namely that significant positive rela-

[44] One important caveat in interpreting these coefficient estimates, potentially the composition of firms' workforces may vary according to subsidies received. Indeed, in unreported regressions, we find that greater subsidies lead firms to hire more female relative to male workers. Part of the negative relationships that we report in certain specifications may reflect a shift towards lower-wage workers.

Table 24: Industry-Province Level Observations

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable	Revenues			Employment			Property, Plant, and Equipment Capital		
Investment Tax Credit	1.280***	1.235***		0.892***	1.150***		1.132***	1.383***	
Rate	(0.181)	(0.216)		(0.157)	(0.172)		(0.221)	(0.239)	
Closed Certificate			0.574***			0.620***			0.706***
			(0.106)			(0.090)			(0.121)
N	238,206	237,747	237,747	236,593	236,148	236,148	237,888	237,422	237,422
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.885	0.913	0.913	0.886	0.924	0.924	0.858	0.887	0.887
Panel B: IV Estimates	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Dependent Variable	Revenues			Employment			Property, Plant, and Equipment Capital		
Investment Tax Credit	4.092***	8.222***		-3.414***	3.651***		1.030	9.074***	
Rate	(0.915)	(1.448)		(0.832)	(1.130)		(1.113)	(1.881)	
Closed Certificate			2.076			1.741			2.484
			(2.170)			(1.814)			(2.863)
N	238,206	237,747	211,457	236,593	236,148	210,335	237,888	237,422	211,239
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
	First Stage								
Statutory Investment	0.068***	0.082***		0.068***	0.082***		0.068***	0.082***	
Tax Credit Rate	(0.004)	(0.007)		(0.004)	(0.007)		(0.004)	(0.007)	
Eligible for Subsidy?			0.023***			0.022***			0.023***
			(0.004)			(0.004)			(0.004)

Notes: See the notes for Table 5. In contrast to that table, observations are weighted equally.

Table 25: Industry-Province Level Observations

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)
Investment Tax Credit	0.967**		1.825***		1.335***	
Rate	(0.489)		(0.506)		(0.506)	
Closed Certificate		0.347**		0.648***		0.463***
		(0.163)		(0.163)		(0.168)
Syrian Refugee	1.183***	1.192***	0.980***	0.998***		
Population Share$_{t-1}$	(0.352)	(0.352)	(0.325)	(0.325)		
N	238,206	238,206	237,747	237,747	237,747	237,747
Year FEs	Yes	Yes	No	No	No	No
Province× Year FEs	No	No	No	No	Yes	Yes
Industry× Year FEs	No	No	Yes	Yes	Yes	Yes
R^2	0.885	0.885	0.913	0.913	0.977	0.977
Panel B: IV Estimates	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Investment Tax Credit	2.001		6.072***		3.409**	
Rate	(1.253)		(2.015)		(1.650)	
Closed Certificate		0.295		0.830		0.262
		(0.881)		(0.942)		(1.138)
Syrian Refugee	1.174***	1.171***	0.948***	1.001***		
Population Share$_{t-1}$	(0.351)	(0.357)	(0.327)	(0.332)		
N	238,206	212,008	237,747	211,457	237,747	211,457
Year FEs	Yes	Yes	No	No	No	No
Province× Year FEs	No	No	No	No	Yes	Yes
Industry× Year FEs	No	No	Yes	Yes	Yes	Yes
	First Stage					
Statutory Investment	0.211***		0.161***		0.151***	
Tax Credit Rate	(0.057)		(0.038)		(0.038)	
Eligible for Subsidy?		0.067***		0.052**		0.046***
		(0.019)		(0.021)		(0.020)

Notes: See the notes for Table 5. In addition to the explanatory variables listed in that table, we include controls for the province's population share that are Syrian refugees (columns 1 trough 4 and 7 through 10) or province-by-year fixed effects (columns 5, 6, 11, and 12).

tionships among subsidization, productivity, and revenues is consistent with little relationship between subsidization and real wages.

Additional Variables Measuring Exposure to Subsidy Policy

In Section 4, our primary measures of subsidization were (i) investment tax credits received, or (ii) an indicator variable: whether the firm has a closed subsidy certificate. In Tables 28 and 29, we consider the relationship between firm-level outcomes with two alternate measures of firm subsidization.

Table 28 relates firm employment and revenues to the the number of years for which the firm is relieved of its mandatory contributions to their employees' social security payments.

Table 26: Industry-Province Level Observations: Firm Counts

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)
Investment Tax Credit	0.791***	0.679***		0.993	1.229**	
Rate	(0.101)	(0.097)		(0.827)	(0.513)	
Closed Certificate			0.334***			0.736***
			(0.054)			(0.269)
N	238,206	237,747	237,747	238,206	237,747	237,747
Year FEs	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes
Weight Observations?	No	No	No	Yes	Yes	Yes
R^2	0.926	0.961	0.961	0.976	0.993	0.993
Panel B: IV Estimates	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Investment Tax Credit	1.713***	3.837***		-0.256	2.102**	
Rate	(0.515)	(0.687)		(1.162)	(1.069)	
Closed Certificate			1.458			1.520
			(0.995)			(1.116)
N	238,206	237,422	211,457	238,206	237,422	211,457
Year FEs	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes
Weight Observations?	No	No	No	Yes	Yes	Yes
		First Stage				
Statutory Investment	0.068***	0.082***		0.211***	0.161***	
Tax Credit Rate	(0.004)	(0.007)		(0.057)	(0.038)	
Eligible for Subsidy?			0.023***			0.052***
			(0.004)			(0.021)

Notes: See the notes for Table 5. In contrast to that table, here the dependent variable is log(Firm Count) in the province-industry for each year.

Consistent with Table 6, subsidization is positively and significantly related to firm revenues and employment. Furthermore, given that the employment-based measure of firm subsidization is approximately 20 times that of the investment-based measure (compare the fifth and eighth rows of Table 3), the magnitudes depicted in Table 28 are similar to those in Tables 6. Our finding that the estimated relationships between firm outcomes and subsidization are invariant to the measure of subsidization reflects the fact that the different subsidies tend to be bundled with one another. Firms receiving a successful subsidy application tend to receive both subsidies to new capital investments and those to increasing or retaining employees.

In Table 29, we present the relationship between the total costs incurred by the government — encompassing both social security rebates and investment tax credits — and firms' employment and revenues. To make the cost variable comparable across firms, we scale this subsidy variable by the firm's size (the value of its plant, property, and equipment capital) as of 2011. As in our other analyses, we find that firm subsidies are positively related to employment and revenues, with estimates in IV than in OLS specifications. The IV estimates indicate that a one percentage point increase in subsidy expenditures (relative to the firm's pre-policy assets)

Table 27: The Impact of the Subsidy Program on Firm Wage-Bill and Average Wages

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable		Wage-Bill			Average Wages per Employee	
Investment Tax Credit Rate	1.097***	1.015***		0.021	-0.003	
	(0.100)	(0.089)		(0.017)	(0.012)	
Closed Certificate			0.454***			-0.002
			(0.033)			(0.006)
N	924,285	924,285	905,069	922,466	922,466	903,269
Year FEs	Yes	No	No	Yes	No	No
Year× Industry FEs	No	Yes	Yes	No	Yes	Yes
R^2	0.881	0.885	0.888	0.918	0.923	0.924
Panel B: IV Estimates	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Variable		Wage-Bill			Average Wages per Employee	
Investment Tax Credit Rate	1.875***	1.370**		0.107	-0.622***	
	(0.497)	(0.675)		(0.131)	(0.136)	
Closed Certificate			2.004**			-0.348*
			(0.927)			(0.205)
N	885,918	885,538	866,233	884,106	883,724	864,439
Year FEs	Yes	No	No	Yes	No	No
Year× Industry FEs	No	Yes	Yes	No	Yes	Yes
			First Stage			
Statutory Investment Tax Credit Rate	0.142***	0.135***		0.142***	0.135***	
	(0.010)	(0.019)		(0.010)	(0.019)	
Eligible for Subsidy?			0.026*			0.026*
			(0.015)			(0.015)

Notes: All regressions include firm fixed effects. Standard errors are clustered at the province level.

increase employment by 0.9 to 1.1 percent and revenues by 1.4 to 2.2 percent.

Firms with All of Their Establishments in a Single Industry-Province Pair

The sample in our benchmark analysis includes firms that have establishments in multiple industry-province pairs. For firms that receive a subsidy from the Turkish government, we observe the location and industry through which the firm receives the subsidy. However, for unsubsidized multi-establishment firms, there is no clear way to define the instrument: Because there are multiple industries or provinces through which a firm may apply for a subsidy, there are multiple potential statutory rates that one could defensibly apply. For this reason, in Table 30, we consider a robustness exercise in which we compare firm-level measures of economic activity — revenues, employment, and TFPR — to subsidization for the subset of firms with all of their establishments in a single industry-province pair. Overall, we find similar results with this restricted sample, with the effects of subsidization somewhat larger for certain specifications (e.g., most of the specifications with employment and revenues as the outcome variable) and comparable in other specifications (e.g., most of the specifications with TFPR as the outcome

Table 28: The Impact of the Subsidy Program on Firm Outcomes

Panel A: OLS Estimates	(1)	(2)	(3)	(4)
Dependent Variable	Employment		Revenues	
SSEP–Years of Support	0.072***	0.068***	0.058***	0.054***
Received+Closed Certificate	(0.006)	(0.006)	(0.005)	(0.005)
N	905,146	905,146	901,332	901,332
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
R^2	0.853	0.858	0.834	0.839
Panel B: IV Estimates	(5)	(6)	(7)	(8)
Dependent Variable	Employment		Revenues	
SSEP–Years of Support	0.136***	0.150**	0.236***	0.270***
Received+Closed Certificate	(0.045)	(0.060)	(0.057)	(0.077)
N	866,693	866,303	862,809	862,407
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
	First Stage			
Statutory Years of Social Security	0.085***	0.082***	0.084***	0.079***
Support	(0.010)	(0.016)	(0.010)	(0.016)

Notes: SSEP refers to the number of years of support for employer's mandatory contributions to social security premiums. All regressions additionally include firm fixed effects. Standard errors are clustered at the province level.

Table 29: The Impact of the Subsidy Program on Firm Outcomes

Panel A: OLS Estimates	(1)	(2)	(3)	(4)
Dependent Variable	Employment		Revenues	
Subsidy Payments Relative	0.499***	0.473***	0.381***	0.362***
to 2011 Revenues	(0.025)	(0.025)	(0.026)	(0.028)
N	886,084	885,704	890,385	890,000
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
R^2	0.847	0.852	0.815	0.820
Panel B: IV Estimates	(5)	(6)	(7)	(8)
Dependent Variable	Employment		Revenues	
Subsidy Payments Relative	0.893***	1.130***	1.446***	2.150***
to 2011 Revenues	(0.225)	(0.338)	(0.258)	(0.461)
N	886,083	885,703	890,384	889,999
Year FEs	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes
	First Stage			
Statutory Investment Tax	0.248***	0.208***	0.248***	0.212***
Credit Rate	(0.023)	(0.038)	(0.024)	(0.039)

Notes: All regressions additionally include firm fixed effects. Standard errors are clustered at the province level.

Table 30: The Impact of the Subsidy Program on Firm Revenues, Employment, and TFP

Panel A: OLS Estimates	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable		Revenues			Employment			TFP	
Investment Tax Credit	0.961***	0.816***		0.989***	0.883***		0.012	-0.028	
Rate	(0.114)	(0.099)		(0.119)	(0.101)		(0.034)	(0.032)	
Closed Certificate			0.461***			0.476***			-0.012
			(0.043)			(0.041)			(0.016)
N	454,877	454,877	448,741	236,593	236,148	236,148	421,369	421,369	413,105
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.860	0.866	0.8670	0.886	0.924	0.924	0.663	0.679	0.684
Panel B: IV Estimates	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Dependent Variable		Revenues			Employment			TFP	
Investment Tax Credit	2.802***	2.587***		1.849***	1.540**		1.151***	0.461**	
Rate	0.599	0.620		(0.549)	(0.653)		(0.185)	(0.223)	
Closed Certificate			2.757***			2.041***			-0.056
			(0.984)			(0.032)			(0.275)
N	422,166	421,542	412,485	425,579	424,964	415,396	391,430	390,768	382,492
Year FEs	Yes	No	No	Yes	No	No	Yes	No	No
Industry× Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
					First Stage				
Statutory Investment	0.134***	0.154***		0.137***	0.159***		0.136***	0.157***	
Tax Credit Rate	(0.009)	(0.016)		(0.009)	(0.017)		(0.009)	(0.017)	
Eligible for Subsidy?			0.031***			0.032***			0.031
			(0.010)			(0.011)			(0.010)

Notes: See the notes for Table 6. In contrast to that table, the sample in the current table includes only firms who have all of their establishment in a single province-industry pair.

variable). In contrast to Table 7, in Table 30 the OLS regression estimates of the relationship between the investment tax credit rate and measured TFP is not statistically significant.

Alternate Productivity Measures

In this section, we reproduce Tables 8 and 9 with two alternate measures of productivity. In our benchmark analysis, we estimated a value added production function with labor (measured by the wage-bill) and capital (measured by the real value of the capital stock, computed using a perpetual inventory method type procedure) as the two inputs. We estimated this production function using the estimator introduced in Ackerberg et al. (2015), using investment and intermediate inputs purchases as the two proxy variables. We found a negative relationship — sometimes not statistically significant — between productivity and subsidization in our OLS regressions, but a positive relationship when subsidization is instrumented with statutory subsidy eligibility and generosity. In Table 31, we re-estimate these relationships between subsidization and productivity with two alternate productivity measures: the logarithm of value added per worker, and the logarithm of TFP, wherein only investment is used as a proxy variable. We find little differences between the results presented in Table 31 and those in Tables 8 and 9.

D.3 Additional Figures Supporting Section 5

In this appendix, we present four additional figures to supplement the analysis in Section 5.

First, Figure 17 displays the average investment tax credit received by firms, by region and by industry, in 2019. As in Figure 5, investment subsidies differ because of both statutory differences in subsidy generosity and the differences in take-up rates across industries and regions. Both take-up rates and subsidy generosity were higher in Region 6 than in other regions, and in manufacturing than in services.

Second, Figure 7 in the body of the paper depicted the impact of the policy on real wages. There, we calibrated the labor productivity and capital returns gains to match estimates, from Section 4.4's firm-level regressions, on the link between investment tax credit rates and TFP. We assumed that $\kappa_z = 1/3$ of the benefits accrued through labor productivity and $\kappa_\tau = 2/3$ through higher capital returns. In Figures 18 and 19, we instead assume that all of the gains enter either through labor productivity (Figure 18) or through capital returns (Figure 19.) In Figure 18, under the calibration with migration, trade, and capital income linkages, the subsidy policy leads to a 2.5 percent decrease in inequality (between Regions 1 and 5) as of 2020, 2.3 percent as of 2030, and 2.3 percent as of 2040. Removing any capital, migration, and trade linkages, the policy leads to a 6.3 percent reduction in real wage inequality by 2040 (between Regions 1 and 6). By contrast, associating the subsidy program with increases in capital returns, the subsidy policy decreases regional real wage inequality by 0.1 percent as of 2020, 0.3 percent as of 2030, and 0.4 percent as of 2040. In economies that exclude migration, trade, and capital income linkages, the subsidy policy would have lead to a 2.2 percent reduction in real wage

Table 31: The Impact of the Subsidy Program on Firm Activity: Alternate Productivity Measures

	VA per Worker				TFP, with Investment as a Proxy Variable			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment Tax Credit	-0.343***	-0.402***	0.927**	0.417	-0.080***	-0.108***	0.984***	0.639***
Rate	(0.062)	(0.054)	(0.439)	(0.475)	(0.030)	(0.028)	(0.206)	(0.186)
Weight of Subsidized	0.019	-0.000	0.017	-0.002	0.001	-0.006	-0.002	-0.008
Firms in Total Sales	(0.013)	(0.014)	(0.012)	(0.013)	(0.007)	(0.007)	(0.007)	(0.007)
Weight of Subsidized	0.040**	0.038*	0.016	0.028	0.055***	0.041***	0.033**	0.031**
Firms in Total Purchases	(0.018)	(0.021)	(0.023)	(0.023)	(0.011)	(0.012)	(0.015)	(0.012)
Log Daily Wage	0.041***	0.021*	0.038***	0.022**	-0.015**	-0.007	-0.018***	-0.007
	(0.010)	(0.011)	(0.010)	(0.010)	(0.007)	(0.006)	(0.007)	(0.006)
N	735,355	735,355	686,630	686,231	791,523	791,523	744,754	744,384
Year FEs	Yes	No	Yes	No	Yes	No	Yes	No
Year× Industry FEs	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.683	0.693			0.645	0.656		
First Stage Estimates								
Statutory investment tax			0.130***	0.117***			0.137***	0.127***
credit rate			(0.010)	(0.018)			(0.010)	(0.020)
Weight of Subsidized			0.002	0.002			0.002	0.002
Firms in Total Sales			(0.002)	(0.001)			(0.002)	(0.001)
Weight of Subsidized			0.017***	0.012***			0.018***	0.013***
Firms in Total Purchases			(0.003)	(0.002)			(0.003)	(0.002)
Log Daily Wage			0.000	-0.001			0.001	-0.001
			(0.001)	(0.001)			(0.001)	(0.001)

Notes: All regressions include firm fixed effects. Standard errors are clustered at the province level.

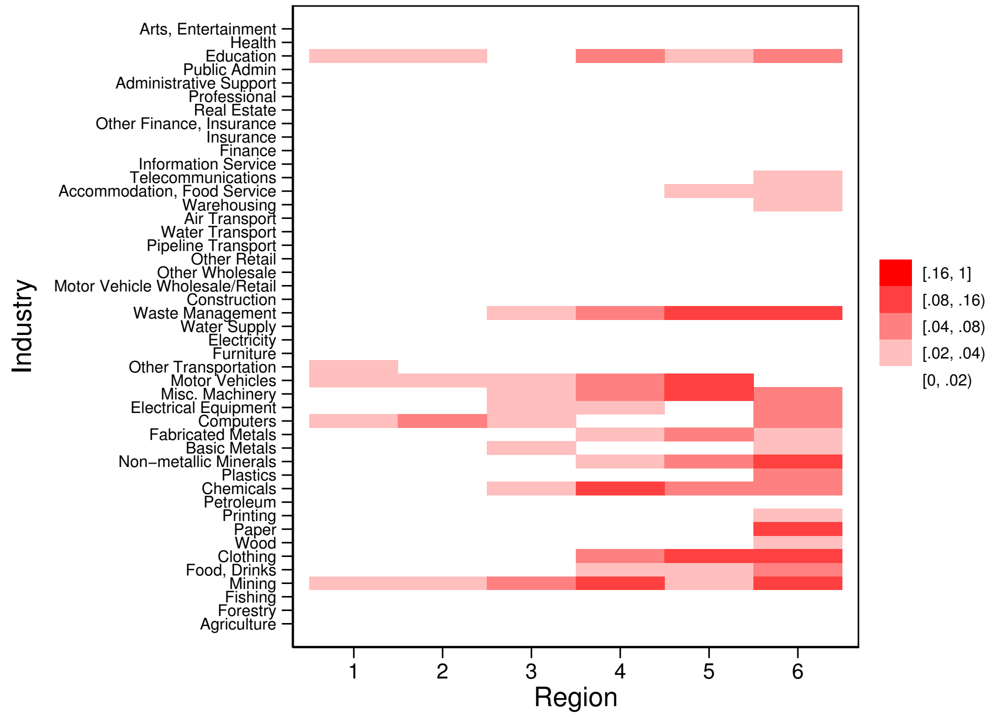

Figure 17: Investment Tax Credit Rates
Notes: The plot gives the average investment tax credit for each region and industry in 2019.

inequality by 2040. So, on the one hand, we find that the subsidy policy has a greater impact — both on average real wages and regional real wage inequality — if it operates through TFP rather than capital returns. Nevertheless, our conclusion that the policy has a relatively modest impact because of migration, capital income, and trade linkages holds in both Figures 18 and 19. Trade and migration linkages play a greater role in Figure 18, whereas capital income linkages are more influential in Figure 19.

Third, Figure 20 depicts the sensitivity of our results to the way in which we calibrate the land share of capital and the strength of agglomeration economies. We plot the impact of the subsidy policy on regional real wage inequality — summarized by the percent increase in real wages in Region 5 vs. Region 1 — as of 2025 (left panels) and 2040 (right panels.) The top panels consider different values of η, a parameter characterizing the extent to which industry productivity in a subsidy region responds to employment in that industry-region. The bottom panels consider different values of the land share of capital, $\frac{\alpha^j}{1-\mu^j}$. Our assessments of the role of the subsidy policy are robust to our choice of η. While our choice of the land share of capital has only a modest impact, overall, we see that lower values of $\frac{\alpha^j}{1-\mu^j}$ correspond to a greater assessed role of the subsidy policy on real wage inequality, especially in the long run. Greater land intensity in production acts as a "congestion force." Relative to a world without the subsidy policy, the 2012 policy leads to more workers in Regions 5 and 6 and lower land per worker

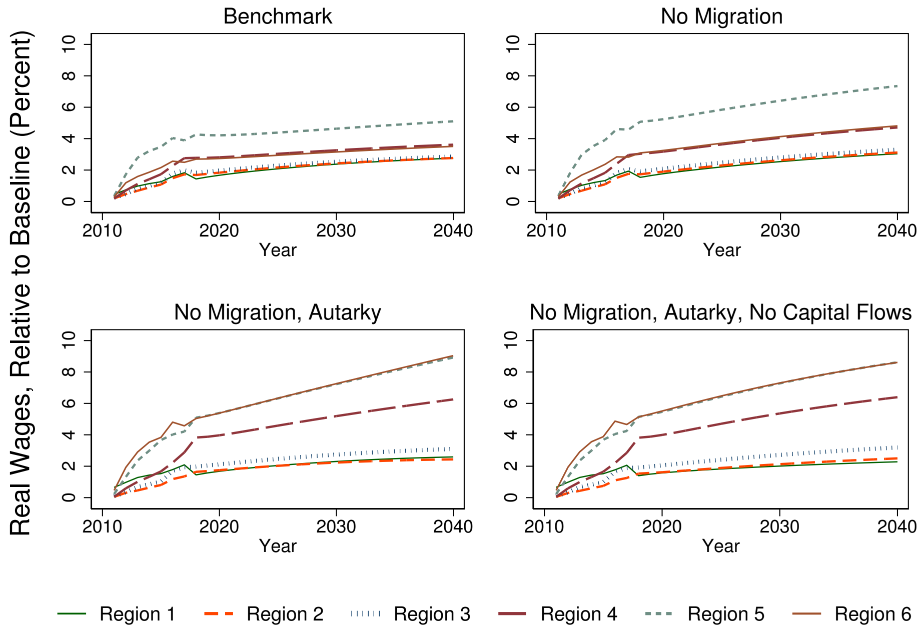

Figure 18: Real Wage Effects of the 2012 Subsidy Program
Notes: See the notes for Figure 7. In contrast to that figure, we suppose all of the gains of the subsidy policy are through labor productivity. Using s_{ijt} to denote 0.647 multiplied by the average investment tax credit rate in region i, industry j, and year t, we set $\mathrm{d}\log z_{ijt} = s_{ijt}$ and $\mathrm{d}\log \tau_{i,t}^{j,K} = 0$.

there. If land intensity is relatively high, this acts as a countervailing force on labor productivity and, as a result, on the real wage impacts of the policy.

Finally, Figure 21 plots the average investment tax credits received by firms in the formal economy. (This is the analogue of Figure 5, which presented our measures of subsidization for both formal economy and informal economy firms.) The measures of subsidization that we observe in the raw data pertain only to formal economy firms. To produce Figure 5, we used the fact that informal-economy firms are ineligible to receive investment subsidies and thus divided the average investment tax credits received by the share of workers in each industry-region pair that is employed in the formal economy (using the method discussed in Appendix A.3.) In Figure 21, instead, we plot the investment tax credits received by the firms appearing in our dataset. These are substantially higher, especially for Region 6: While the 2019 value for average investment tax credits received was 1.3 percent, here it is 3.3 percent. In Figure 22, we plot counterfactual wage impacts of the subsidy program in which we apply the subsidization rates in Figure 21. Here, the implied impacts of the subsidy program are magnified compared to those in Figure 9.

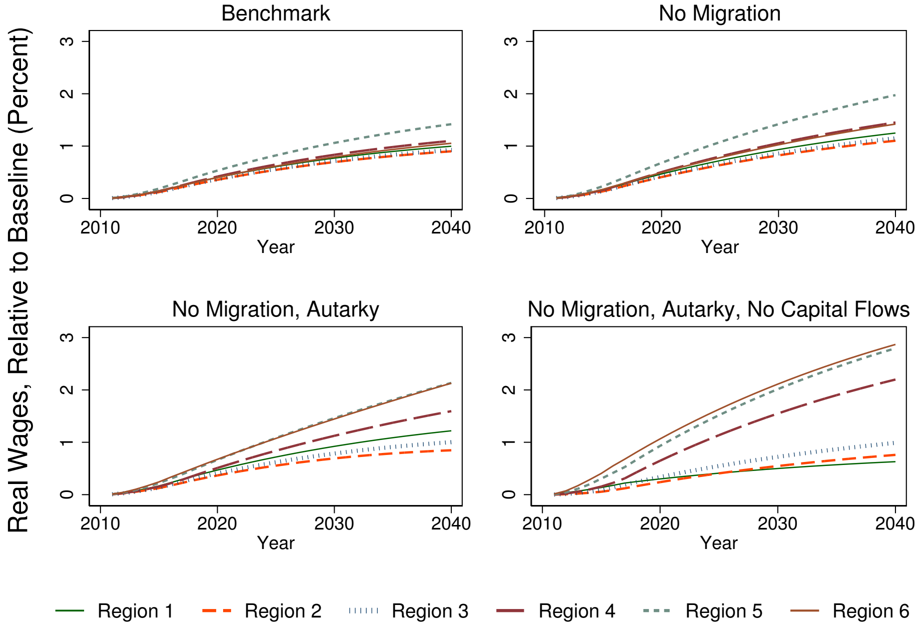

Figure 19: Real Wage Effects of the 2012 Subsidy Program
Notes: See the notes for Figure 7. In contrast to that figure, we impose that all of the gains of the subsidy policy are through capital returns wedges. Using s_{ijt} to denote 0.647 multiplied by the average investment tax credit rate in region i, industry j, and year t, we set $\mathrm{d}\log z_{ijt} = 0$ and $\mathrm{d}\log \tau_{i,t}^{j,K} = -\frac{s_{ijt}}{\gamma^j(1-\mu^j-\alpha^j)}$.

E Theoretical Appendix

E.1 Outline of the Model and Its Solution

Our model adapts an extension of Kleinman et al. (2023), outlined in their Online Supplement S.4.5. We modify this model in a few dimensions. First, we incorporate not only productivity shocks but also "wedge" shocks to capital investors' returns to capital. In addition, we consider (i) agglomeration in productivity (as in Online Supplement S.4.2 of Kleinman et al., 2023), (ii) non-employment (as in appendix S.4.9), and (iii) capital investor investment in locations other than where they reside (with a formulation similar to, but distinct from, Online Supplement S.4.8). Finally, unlike in any of the variants of the models considered in Kleinman et al. (2023), but as in Caliendo et al. (2019), we include land as a factor of production. The non-reproducibility of land will serve as a potentially important "congestion force" in the model. A final distinction from Online Supplement S.4.5 of Kleinman et al. (2023): We assume that migration costs, iceberg trade costs, and location-specific amenities do not vary over time.

Where applicable, portions of the appendix below draw directly on the exposition of Online Supplement S.4.5 of Kleinman et al. (2023), quoting verbatim.

We consider an economy that consists of many locations (also called, interchangeably, "re-

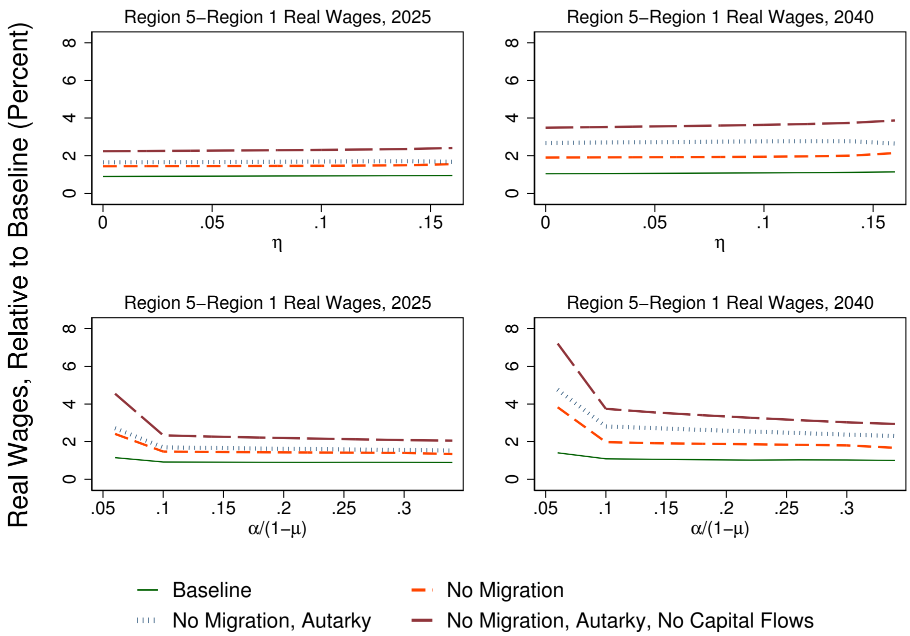

Figure 20: Impact of the subsidy policy as on Region 5 vs. Region 1 Inequality
Notes: This plot gives the impact of the subsidy policy on Region 5 vs. Region 1 inequality. In the top panels, we keep all parameters except for η at their benchmark values; we vary η from 0 to 0.16. In the bottom panels, we keep all parameters except for $\alpha^j/\left(1-\mu^j\right)$ at their benchmark values; we vary $\alpha^j/\left(1-\mu^j\right)$ from 0.02 to 0.30.

gions") indexed by $i \in \{1, \ldots, N\}$ and many sectors (also called, interchangeably, "industries") indexed by $j \in \{0, 1, \ldots, J\}$; industry 0 indexes non-employment. Time is discrete and is indexed by t. The economy consists of three types of infinitely-lived agents: workers (sometimes also called "households"), capital investors, and landlords. Workers, landlords, and capital investors have the same flow preferences, which are modeled as in the standard Armington model of international trade. Workers are endowed with one unit of labor that is supplied inelastically to a single industry (or to non-employment). They are geographically mobile across sectors and locations subject to bilateral migration costs. Workers do not have access to an investment technology and live hand to mouth as in Kaplan and Violante (2014). Capital investors are geographically immobile and own capital both in their region and elsewhere in the country. They make a forward-looking decision over consumption and investment in this local stock of capital. We assume that capital is geographically immobile once installed, but depreciates gradually at a constant rate δ. Finally, landlords (like capital investors) are geographically immobile. They own a portfolio of land throughout the country. Land is a fixed factor, so they make no forward-looking investment decisions. They simply consume the income they earn from renting out land.

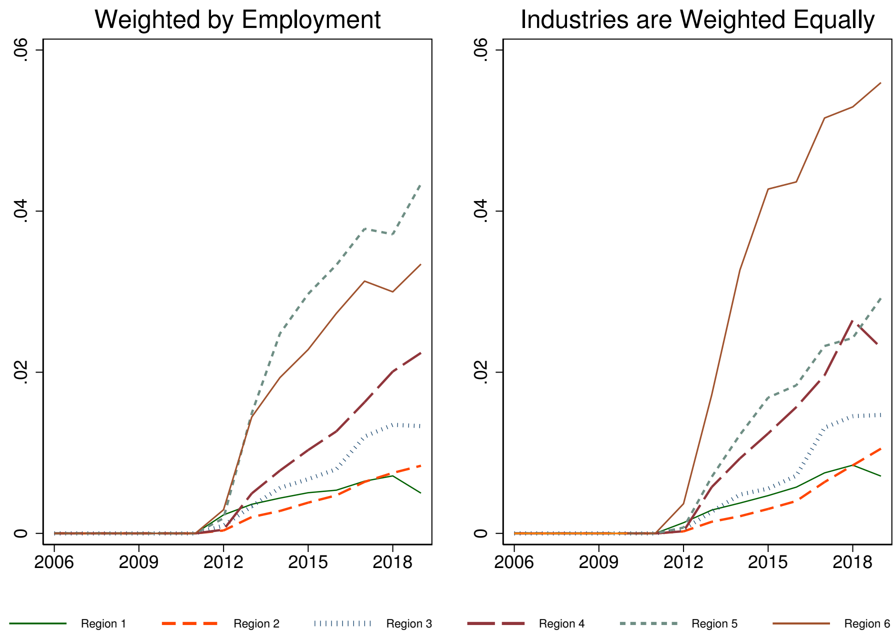

Figure 21: Investment Tax Credit Rates
Notes: See the notes for Figure 5. In contrast to that figure, we do not attempt to account for the incomplete nature of the EIS data.

E.1.1 Worker Migration Decisions

At the beginning of each period t, the economy inherits a mass of workers in each sector j and location i (ℓ_{it}^{j}) with the total labor endowment of the economy given by $\bar{\ell} = \sum_{i=1}^{N} \sum_{j=0}^{J} \ell_{it}^{j} = 1$. Workers produce and consume in their sector and location in period t, before observing mobility shocks $\left\{\epsilon_{gt}^{h}\right\}$ for all possible sectors $h \in \{0, 1, \ldots, J\}$ and locations $g \in \{1, \ldots, N\}$ and deciding where to move for period $t+1$. Workers face bilateral migration costs that vary by sector and location, where κ_{gi}^{hj} denotes the cost of moving from sector j in location i to sector h in location g. The value function for a worker in sector j and location i at time t $\left(\mathbb{V}_{it}^{j,w}\right)$ is equal to the current flow of utility in that sector and location plus the expected continuation value next period from the optimal choice of sector and location:

$$\mathbb{V}_{it}^{j,w} = \log u_{it}^{j,w} + \max_{\{g\}_1^N \{h\}_0^J} \left\{\beta \mathbb{E}_t \left[\mathbb{V}_{g,t+1}^{h,w}\right] - \kappa_{gi}^{hj} + \rho \epsilon_{gt}^{h}\right\} ,$$

where we use the superscript w to denote workers; we assume logarithmic flow utility; β denotes the discount factor; $\mathbb{E}[\cdot]$ denotes an expectation taken over the distribution for idiosyncratic mobility shocks; ρ captures the dispersion of idiosyncratic mobility shocks; and we assume $\kappa_{ii}^{jj} = 1$ and $\kappa_{gi}^{hj} > 1$ for $g \neq i$ or $h \neq j$.

We make the conventional assumption that the idiosyncratic mobility shocks are drawn from

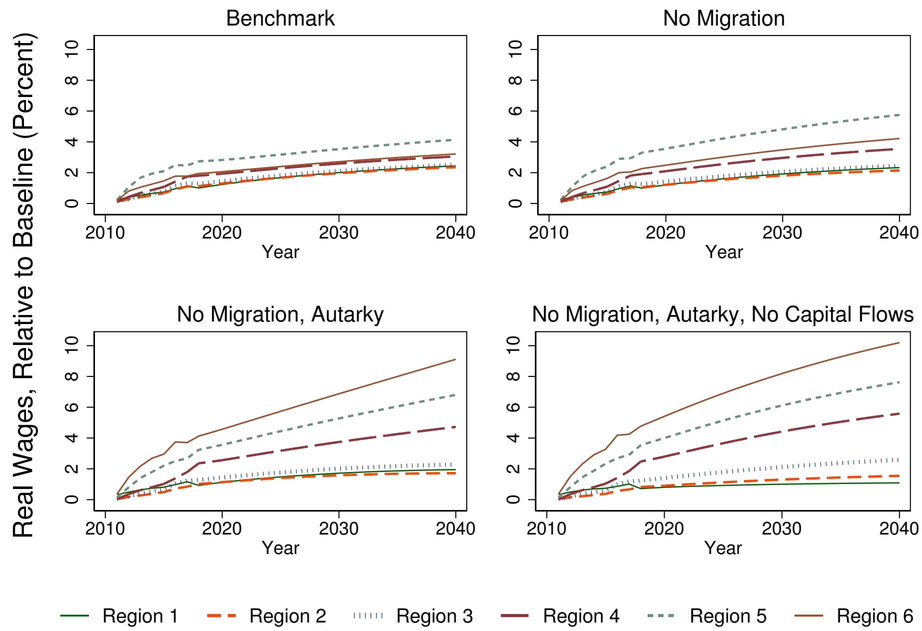

Figure 22: Real Wage Effects of the 2012 Subsidy Program
Notes: See the notes for Figure 7. In contrast to that figure, in our calibration of trade and worker flows across industry-subsidy region pairs and in our calibration of the average investment tax credits received by industry and subsidy region, we do not make any adjustments for firms and employment in the informal economy.

an extreme value distribution:

$$F(\epsilon) = e^{-e^{(-\epsilon-\bar{\gamma})}} ,$$

where $\bar{\gamma}$ is the Euler-Mascheroni constant. Under this assumption, the expected value for a worker from living in location i and working in industry j at time t $\left(v_{it}^{j,w}\right)$ can be re-written in the following form:

$$v_{it}^{j,w} = \log u_{it}^{j,w} + \rho \log \sum_{g=1}^{N} \sum_{h=0}^{J} \left(\exp\left(\beta \mathbb{E}_t v_{g,t+1}^{h,w}\right) / \kappa_{gi}^{hj} \right)^{1/\rho} .$$

The corresponding probability of migrating from location-sector ij to location-sector gh satisfies a gravity equation:

$$D_{igt}^{jh} = \frac{\left(\exp\left(\beta \mathbb{E}_t v_{g,t+1}^{h,w}\right) / \kappa_{gi}^{hj} \right)^{1/\rho}}{\sum_{m=1}^{N} \sum_{o=0}^{J} \left(\exp\left(\beta \mathbb{E}_t v_{m,t+1}^{o,w}\right) / \kappa_{mi}^{oj} \right)^{1/\rho}} .$$

The population flow condition implies:

$$\ell_{g,t+1}^{h} = \sum_{i=1}^{N} \sum_{j=0}^{J} D_{igt}^{jh} \ell_{it}^{j} .$$

We also define a corresponding in-migration probability E_{git}^{hj}, which captures the share of workers in destination g and sector h at time $t+1$ that in-migrated from origin i and sector j at time t:

$$E_{git}^{hj} \equiv \frac{\ell_{it}^{j} D_{igt}^{jh}}{\ell_{g,t+1}^{h}} .$$

Note that the order of subscripts switches between the out-migration probability and the in-migration probability, because the first and second subscripts will correspond below to rows and columns of a matrix, respectively.

E.1.2 Worker Consumption

Worker preferences follow the standard Armington model of trade. As workers do not have access to an investment technology, they choose their consumption of varieties each period to maximize their flow utility in their location and sector that period. Worker flow indirect utility in location n and sector j depends on local amenities (b_n^j), the wage $\left(w_{nt}^j\right)$, and the consumption goods price index (P_{nt}) :

$$\begin{aligned} \log u_{nt}^{j,w} &= \log b_n^j + \log w_{nt}^j - \log P_{nt} \text{ for } j > 0 \text{ and} \\ &= \log b_n^0 \text{ for } j = 0 , \end{aligned}$$

where amenities (b_n) capture characteristics of a location that make it a more attractive place to live regardless of the wage and cost of consumption goods (e.g., climate and scenic views). We assume that amenities are exogenous and fixed.

The consumption goods price index (P_{nt}) in location n depends on the consumption goods price index for each sector h in that location (p_{nt}^h):

$$P_{nt} = \prod_{h=1}^{J} \left(p_{nt}^h\right)^{\psi^h} , \quad 0 < \psi^h < 1, \quad \sum_{h=1}^{J} \psi^h = 1 , \tag{6}$$

where ψ^h is the share of commodity h in households' preferences. Furthermore, the consumption goods price index for each sector h in location n depends on the price of the variety sourced from each location i within that sector h $\left(p_{nit}^h\right)$:

$$p_{nt}^h = \left[\sum_{i=1}^{N} \left(p_{nit}^h\right)^{-\theta}\right]^{-1/\theta} , \quad \theta = \sigma - 1, \quad \sigma > 1 . \tag{7}$$

Here, $\sigma > 1$ is the elasticity of substitution between varieties; $\theta = \sigma - 1$ is the trade elasticity; and for simplicity, we assume a common elasticity of substitution and trade elasticity across all sectors.

Utility maximization implies that goods consumption expenditure on each sector $\left(p_{nt}^h c_{nt}^h\right)$ is a constant share of overall goods consumption expenditure $(P_{nt} c_{nt})$ in each location:

$$p_{nt}^h c_{nt}^h = \psi^h P_{nt} c_{nt} . \tag{8}$$

Using constant elasticity of substitution (CES) demand for individual varieties of goods, the share of location n's expenditure within sector h on the goods produced by location i is:

$$S^h_{nit} \equiv \frac{\left(p^h_{nit}\right)^{-\theta}}{\sum_{m=1}^{N}\left(p^h_{nmt}\right)^{-\theta}} \,. \tag{9}$$

E.1.3 Production

Producers in each location i and sector j ($j > 0$) use labor, capital, intermediate inputs, and land to produce the variety supplied by that location in that sector. Production is assumed to occur under conditions of perfect competition and subject to the following unit cost function:

$$\mathbb{C}^j_{it} \;=\; \left[\left(\frac{w^j_{it}}{z^j_{it}}\right)^{\mu^j}\left(r^j_{it}\right)^{1-\mu^j-\alpha^j}\left(\tilde{r}^j_{it}\right)^{\alpha^j}\right]^{\gamma^j}\prod_{h=1}^{J}\left(p^h_{it}\right)^{\gamma^{j,h}} \text{ where } \gamma^j + \sum_{h=1}^{J}\gamma^{j,h} = 1.$$

In this cost function, $(1-\gamma^j)$ is the share of intermediates in production costs; $\gamma^{j,h}$ is the share of materials from sector h used in sector j; z^j_{it} denotes labor-augmenting productivity in location i in sector j at time t; μ^j denotes the labor share of value added; and α^j denotes the land share of value added. In this cost function, w^j_{it}, r^j_{it}, and $\tilde{r}^j_{it}$ denote, respectively, the wage, rental price of capital, and rental price of land in region i and sector j. Compared to Kleinman et al. (2023), we include land as a factor of production. Also unlike in the model outlined in Online Supplement S.4.5 of Kleinman et al. (2023), z^j_{it} depends on the number of workers in the industry-sector pair: $z^j_{it} = \bar{z}^j_{it}\left(\bar{\ell}^j_{it}\right)^{\eta}$. Here, $\bar{\ell}^j_{it}$ is the total labor employed in region i and industry j and $\bar{z}^j_{it}$ is the exogenous component to productivity. We include an overbar to emphasize that this is the equilibrium employment, where the agglomeration economies are external to each representative firm in the sector-location pair.

We assume that trade between locations is subject to iceberg variable costs of trade, such that $\tau^j_{ni} \geq 1$ units of a good must be shipped from location i in order for one unit to arrive in location n, where $\tau^j_{ni} > 1$ for $n \neq i$ and $\tau^j_{ii} = 1$. From profit maximization, the cost to a consumer in location n of sourcing the good produced by location i within sector j is:

$$\begin{aligned} p^j_{nit} &= \tau^j_{ni}p^j_{iit} \\ &= \tau^j_{ni}\left[\left(\frac{w^j_{it}}{z^j_{it}}\right)^{\mu^j}\left(r^j_{it}\right)^{1-\mu^j-\alpha^j}\left(\tilde{r}^j_{it}\right)^{\alpha^j}\right]^{\gamma^j}\prod_{h=1}^{J}\left(p^h_{it}\right)^{\gamma^{j,h}} \,, \end{aligned} \tag{10}$$

where p^h_{iit} is the "free on board" price of the good supplied by location i before transport costs.

From the profit maximization problem and zero-profit condition, payments for labor, capital, and land in each sector are constant shares of revenue in that sector:

$$w^j_{it}\ell^j_{it} = \gamma^j\mu^j y^j_{it} \,, \tag{11}$$

$$r^j_{it}k^j_{it} = \gamma^j\left(1-\mu^j-\alpha^j\right)y^j_{it} \,, \tag{12}$$

$$\tilde{r}^j_{it}\tilde{k}^j_i = \gamma^j \alpha^j y^j_{it} \; , \tag{13}$$

where ℓ^j_{it} is the labor input; k^j_{it} is the capital input; $\tilde{k}^j_i$ is the land input (which, note, is time invariant); and y^j_{it} is revenue. The immobility of capital across sectors and locations once installed implies that the rate of return on capital need not be equalized across sectors and locations out of steady-state $\left(r^j_{it} \neq r^h_{nt}\right)$. The same is true for the returns to land, $\left(\tilde{r}^j_{it} \neq \tilde{r}^h_{nt}\right)$.

E.1.4 Landlord and Investor Consumption

Land and Landlords Landlords are indexed by region n. They own an exogenous fixed share of land from throughout the country. In each period, they consume the income they receive from renting out their land.

Let $\sum_{i=1}^{N}\sum_{j=1}^{J}\tilde{r}^j_{it}\tilde{k}^j_i$ be the total revenues in the national land portfolio and ς^n be the share of the national portfolio that is accrued by landlords in region n.

Capital Allocation Across Industries and Regions Unlike the other portions of this section of the online appendix, the next three and a half pages draw, in part, on the exposition of Online Supplement S.4.8 of Kleinman et al. (2023). Whereas, in this appendix, Kleinman et al. (2023) refer to those individuals who invest in capital as "landlords," we will use the term "capital investors" (or "investors").

At the beginning of period t, capital investors in location n and industry j inherit an existing stock of capital $\mathcal{K}^j_{nt}$. (Note the difference in notation: $\mathcal{K}^j_{nt}$ refers to the capital held by investors located in region n and industry j, while $k_{nj,t}$ refers to the capital that is rented to firms in region n and industry j.) Capital investors decide how much to invest in accumulating additional capital and where these investments will go. Once these decisions have been made, production and consumption occur. At the end of period t, new capital is created from the investment decisions made at the beginning of the period, and the depreciation of existing capital occurs. In the remainder of this subsection, we characterize capital investors' decisions at the beginning of the period t of where to allocate the existing capital stock. In the next subsection, we characterize investors' optimal consumption-investment decision.

We assume that, for investors from location-industry nj, a fraction $\phi_{nj\rightarrow ih}$ of their capital is invested in region i and industry h. In the benchmark model of Kleinman et al. (2023), $\phi_{nj\rightarrow ih} = 1$ if $nj = ih$ and 0 otherwise. Note as well these exogenous and constant capital holdings shares is distinct from Online Supplement S.4.8 of Kleinman et al. (2023). Finally, let $\mathcal{R}^h_{i,t}$ denote the gross return on capital held by investors from region-industry ih.

The total stock of capital located in region-industry ih equals the sum of the capital owned by investors across source locations nj.

$$k^h_{it} = \sum_{j=1}^{J}\sum_{n=1}^{N}\phi_{nj\rightarrow ih}\mathcal{K}^j_{nt} \; .$$

The returns for investors residing in region i and industry h equals a weighted average of the returns to capital located in different location-industry (nj) pairs. We assume that there is a *capital returns wedge*, $\tau^K_{nj,t}$. This wedge shifts the returns to capital held in region n and industry j. With these wedges, the returns for investors are given by:

$$\mathcal{R}^h_{it} = \sum_{j=1}^{J}\sum_{n=1}^{N}\phi_{ih\to nj}\left(\frac{r^j_{nt}}{\tau^K_{nj,t}}\right) \; .$$

For future reference, define the matrix $\widetilde{\Lambda}$, where the ijth row and nhth column is given by

$$\widetilde{\lambda}_{ij\to nh} = \frac{\phi_{ij\to nh} r^{h*}_{n}/\tau^{K*}_{nh}}{\sum_{h'=1}^{J}\sum_{n'=1}^{N}\phi_{ij\to n'h'} r^{h'*}_{n'}/\tau^{K*}_{n'h'}},$$

where the * superscript denotes variables at their steady-state values.

Furthermore, we will calibrate $\phi_{ij\to nh}$ so that $\widetilde{\lambda}_{ij\to nh}$ satisfies

$$\widetilde{\lambda}_{ij\to nh} = \begin{cases} \lambda + l^*_{nh}\cdot\left(\sum_{n'=1}^{N} l^*_{n'h}\right)^{-1}(1-\lambda) \text{ if } i=n \text{ and } j=h \text{ , and} \\ l^*_{nh}\cdot\left(\sum_{n'=1}^{N} l^*_{n'h}\right)^{-1}(1-\lambda)\,\Sigma^{jh}_{im} \text{ if } i\neq n \text{ and } j=h \text{ , and} \\ 0 \text{ otherwise.} \end{cases}$$

In other words, capital investors are industry specific. They hold all of their capital in the industry in which they are denominated. They invest a share λ of their capital in their home region-industry pair. In addition, they invest $(1-\lambda)$ of their capital in each of the N regions, with a share proportional to the size of region n within industry h's labor force.

Capital Accumulation Across Periods Capital investors in each location choose their consumption and capital investment to maximize their intertemporal utility subject to their (intertemporal) budget constraint.

Capital investors' intertemporal utility equals the present discounted value of their flow utility, which we assume for simplicity takes the same logarithmic form as for workers:

$$v^k_{ijt} = \sum_{t=0}^{\infty}\beta^t \log c^k_{ijt} \; .$$

Here, we use the superscript k to denote capital investors; c^k_{ijt} is the consumption index for investors in location i and industry j; and β denotes the discount factor. Since investors are immobile, we omit the term in amenities from their flow utility, because this does not affect the equilibrium in any way, and hence is without loss of generality.

The consumption goods index for capital investors $\left(c^k_{ijt}\right)$ takes exactly the same form as for workers and is a Cobb-Douglas aggregate of consumption indices for each sector, where these consumption indexes for each sector are constant elasticity of substitution (CES) functions of the consumption of varieties from each location. Therefore, the consumption goods price index (P_{nt}) takes the same form as in Equation 6, and the consumption goods price index for each sector $\left(p_{nt}^j\right)$ takes the same form as in Equation 7.

Under these assumptions, capital investors' utility maximization problem is weakly separable. First, we solve for the optimal consumption-savings decision across time periods for overall goods consumption. Second, we solve for the optimal allocation of consumption across sectors within each time period. Third, we solve for the optimal allocation of consumption across location varieties within each sector.

Beginning with capital investors' optimal consumption-saving decision, we assume that the investment technology for capital in each location and sector uses the varieties from all locations with the same functional form as consumption. Capital investors in a location can produce one unit of capital using one unit of the consumption index for that location and sector. We assume that capital is immobile across geographies and industries once installed and depreciates at a constant rate δ. The intertemporal budget constraint for investors in each location requires that total income from the existing stock of capital $\left(\mathcal{R}_{it}^j\mathcal{K}_{it}^j\right)$ equals the total value of goods consumption $\left(P_{it}c_{it}^{j,k}\right)$ and net investment ($\mathcal{K}_{it+1}^j - (1-\delta)\,\mathcal{K}_{it}^j$):

$$\mathcal{R}_{it}^j\mathcal{K}_{it}^j = P_{it}c_{it}^{j,k} + P_{it}\left(\mathcal{K}_{i,t+1}^j - (1-\delta)\,\mathcal{K}_{it}^j\right)$$

Combining capital investors' intertemporal utility and budget constraint, their intertemporal optimization problem is:

$$\max_{\left\{c_{it}^{j,k},\mathcal{K}_{i,t+1}^j\right\}} \sum_{t=0}^{\infty} \beta^t \log c_{it}^{j,k}$$

subject to

$$\mathcal{R}_{it}^j\mathcal{K}_{it}^j = P_{it}c_{it}^{j,k} + P_{it}\left(\mathcal{K}_{i,t+1}^j - (1-\delta)\,\mathcal{K}_{it}^j\right).$$

We can write this problem as the following Lagrangian:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \log c_{it}^{j,k} - \xi_{it}^j\left[P_{it}c_{it}^{j,k} + P_{it}\left(\mathcal{K}_{it+1}^j - (1-\delta)\,\mathcal{K}_{it}^j\right) - \mathcal{R}_{it}^j\mathcal{K}_{it}^j\right] .$$

The first-order conditions are:

$$\left\{c_{it}^{jk}\right\} : \frac{\beta^t}{c_{it}^{j,k}} - P_{it}\xi_{it}^j = 0 .$$

$$\left\{\mathcal{K}_{i,t+1}^j\right\} : \left(\mathcal{R}_{i,t+1}^j + P_{i,t+1}(1-\delta)\right)\xi_{i,t+1}^j - P_{it}\xi_{it}^j = 0 .$$

Together these first-order conditions imply:

$$\frac{c_{i,t+1}^{j,k}}{c_{it}^{j,k}} = \beta\frac{P_{it}\xi_{it}^j}{P_{it+1}\xi_{i,t+1}^j} = \beta\left(\frac{\mathcal{R}_{i,t+1}^j}{P_{i,t+1}} + (1-\delta)\right) , \tag{14}$$

where the transversality condition implies:

$$\lim_{t\to\infty} \beta^t \frac{\mathcal{K}_{i,t+1}^j}{c_{it}^{j,k}} = 0 .$$

Our assumption of logarithmic flow utility and the property that the intertemporal budget constraint is linear in the stock of capital together imply that capital investors' optimal consumption-saving decision involves a constant saving rate, as in Moll (2014). We conjecture the following policy functions:

$$P_{it}c_{it}^{j,k} = (1-\beta)\left(\mathcal{R}_{it}^{j} + P_{it}(1-\delta)\right)\mathcal{K}_{it}^{j} \ . \tag{15}$$

$$\mathcal{K}_{i,t+1}^{j} = \beta\left(\frac{\mathcal{R}_{it}^{j}}{P_{it}} + (1-\delta)\right)\mathcal{K}_{it}^{j} \ . \tag{16}$$

Substituting the consumption policy function (Equation 15) into the Euler equation (Equation 14), we confirm that these conjectured policy functions are indeed the optimal consumption-savings choice:

$$\begin{aligned}\frac{c_{i,t+1}^{jk}}{c_{it}^{jk}} &= \frac{\left(\mathcal{R}_{i,t+1}^{j}/P_{i,t+1} + (1-\delta)\right)\mathcal{K}_{i,t+1}^{j}}{\left(\mathcal{R}_{it}^{j}/P_{it} + (1-\delta)\right)\mathcal{K}_{it}^{j}} \\ &= \beta\left(\mathcal{R}_{i,t+1}^{j}/P_{i,t+1} + (1-\delta)\right) \ .\end{aligned}$$

Given this optimal consumption-saving decision in Equations 15 to 16, our assumption of Cobb-Douglas preferences across sectors implies that investors allocate constant shares of consumption expenditure across sectors within time periods, as for workers in Equation 8. Similarly, our assumption of constant elasticity of substitution (CES) preferences across locations within sectors implies that investors in location n allocate the same share of expenditure on location i within sector j, as for workers in Equation 9.

E.1.5 Goods Market Clearing

Goods market clearing implies that income in each location and sector equals expenditure on the goods produced in that location and sector:

$$y_{it}^{j} = \sum_{n=1}^{N} S_{nit}^{j} x_{nt}^{j} \ ,$$

where y_{it}^{j} is total income in sector j in location i and x_{nt}^{j} is total expenditure on industry j in region n at time t. Total expenditure is the sum of final consumption and intermediate goods expenditure and is given by:

$$x_{nt}^{j} = \psi^{j}\left(\sum_{h=1}^{J}\left(w_{nt}^{h}\ell_{nt}^{h} + r_{nt}^{h}k_{nt}^{h} + \tilde{r}_{nt}^{h}\tilde{k}_{nt}^{h}\right)\right) + \sum_{h=1}^{J}\gamma^{h,j}y_{nt}^{h} \ .$$

Combining these two relationships, we have:

$$y_{it}^{j} = \sum_{n=1}^{N} S_{nit}^{j}\left[\psi^{j}\sum_{h=1}^{J}\left(w_{nt}^{h}\ell_{nt}^{h} + r_{nt}^{h}k_{nt}^{h} + \tilde{r}_{nt}^{h}\tilde{k}_{nt}^{h}\right) + \sum_{h=1}^{J}\gamma^{h,j}y_{nt}^{h}\right] \ ,$$

which can be re-written as:

$$y_{it}^{j}=\sum_{n=1}^{N}\sum_{h=1}^{J}S_{nit}^{j}\left[\psi^{j}\gamma^{h}+\gamma^{h,j}\right]y_{nt}^{h}\ . \tag{17}$$

E.1.6 Capital and Land Market Clearing

Using the property that payments to capital and labor are constant shares of total revenue in Equations 11 and 12, we can write payments for capital in each sector as:

$$r_{it}^{j}=\frac{1-\mu^{j}-\alpha^{j}}{\mu^{j}k_{it}^{j}}w_{it}^{j}\ell_{it}^{j}\ . \tag{18}$$

A similar line of reasoning applied to Equations 11 and 13 implies:

$$\tilde{r}_{it}^{j}\ =\ \frac{\alpha^{j}}{\mu^{j}\tilde{k}_{i}^{j}}w_{it}^{j}\ell_{it}^{j}\ . \tag{19}$$

E.1.7 Comparative Statics

We now totally differentiate the conditions for general equilibrium to obtain comparative static expressions that we use in our sufficient statistics for changes in steady-state and the entire transition path.

Industry Price Indices Totally differentiating the industry consumption goods price index in Equation 7, we have:

$$\frac{\mathrm{d}p_{nt}^{j}}{p_{nt}^{j}}=\sum_{\mathrm{m=1}}^{\mathrm{N}}S_{nmt}^{j}\frac{\mathrm{d}p_{nmt}^{j}}{p_{nmt}^{j}}\Rightarrow\mathrm{d}\log p_{nt}^{j}=\sum_{m=1}^{N}S_{nmt}^{j}\ \mathrm{d}\log p_{nmt}^{j}\ . \tag{20}$$

Prices Using the relationship between capital and labor payments (Equation 18), the pricing rule (Equation 10) can be re-written as follows:

$$\begin{aligned}p_{nit}^{j}\ =\ &\tau_{ni}^{j}\left(\frac{w_{it}^{j}}{\left(\bar{z}_{it}^{j}\right)^{\mu^{j}}\left(\ell_{it}^{j}\right)^{\eta\mu^{j}}}\right)^{\gamma^{j}}\left(\frac{1-\mu^{j}-\alpha^{j}}{\mu^{j}}\right)^{\left(1-\mu^{j}-\alpha^{j}\right)\gamma^{j}}\left(\frac{\alpha^{j}}{\mu^{j}}\right)^{\alpha^{j}\gamma^{j}}\\&\times\left(\frac{1}{\chi_{it}^{j}}\right)^{\left(1-\mu^{j}-\alpha^{j}\right)\gamma^{j}}\left(\frac{\ell_{it}^{j}}{\tilde{k}_{i}^{j}}\right)^{\alpha^{j}\gamma^{j}}\prod_{h=1}^{J}\left(p_{it}^{h}\right)^{\gamma^{j,h}},\end{aligned}$$

where $\chi_{it}^{j}\equiv k_{it}^{j}/\ell_{it}^{j}$ is the capital-labor ratio in sector j in (source) region i and ℓ_{it}^{j} is the employment in region i and industry j. (Note that, in the equation near the top of page 77 in the online supplement of Kleinman et al., 2023, the coefficient on productivity is given by γ^{j} instead of $\gamma^{j}\mu^{j}$ as it is here.)

Totally differentiating this pricing rule, we have:

$$\frac{\mathrm{d}p_{nit}^{j}}{p_{nit}^{j}} = \gamma^{j}\frac{\mathrm{d}w_{it}^{j}}{w_{it}^{j}} - \gamma^{j}\left(1-\mu^{j}-\alpha^{j}\right)\frac{\mathrm{d}\chi_{it}^{j}}{\chi_{it}^{j}} \tag{21}$$

$$- \gamma^{j}\mu^{j}\,\frac{\mathrm{d}\bar{z}_{it}^{j}}{\bar{z}_{it}^{j}} - \gamma^{j}\left(\eta\mu^{j}-\alpha^{j}\right)\frac{\mathrm{d}\ell_{it}^{j}}{\ell_{it}^{j}} + \sum_{h=1}^{J}\gamma^{j,h}\frac{\mathrm{d}p_{it}^{h}}{p_{it}^{h}}\ .$$

$$\mathrm{d}\log p_{nit}^{j} = \gamma^{j}\ \mathrm{d}\log w_{it}^{j} - \gamma^{j}\left(1-\mu^{j}-\alpha^{j}\right)\ \mathrm{d}\log \chi_{it}^{j}$$

$$- \gamma^{j}\mu^{j}\ \mathrm{d}\log \bar{z}_{it}^{j} - \gamma^{j}\left(\mu^{j}\eta-\alpha^{j}\right)\mathrm{d}\log \ell_{it}^{j} + \sum_{h=1}^{J}\gamma^{j,h}\ \mathrm{d}\log p_{it}^{h}\ .$$

Combining the total derivatives of the aggregate price index (Equation 20) and industry prices (Equation 21), we have:

$$\mathrm{d}\log p_{nit}^{j} = \gamma^{j}\ \mathrm{d}\log w_{it}^{j} - \gamma^{j}\left(\eta\mu^{j}-\alpha^{j}\right)\mathrm{d}\log \ell_{it}^{j} - \left(1-\mu^{j}-\alpha^{j}\right)\gamma^{j}\ \mathrm{d}\log \chi_{it}^{j}$$

$$- \gamma^{j}\mu^{j}\ \mathrm{d}\log \bar{z}_{it}^{j} + \sum_{h=1}^{J}\sum_{m=1}^{N}\gamma^{j,h}S_{imt}^{h}\ \mathrm{d}\log p_{imt}^{h}\ ,$$

which can be re-written as:

$$\mathrm{d}\log p_{nit}^{j} = \gamma^{j}\ \mathrm{d}\log w_{it}^{j} - \gamma^{j}\left(\eta\mu^{j}-\alpha^{j}\right)\mathrm{d}\log \ell_{it}^{j} - \left(1-\mu^{j}-\alpha^{j}\right)\gamma^{j}\ \mathrm{d}\log \chi_{it}^{j}$$

$$- \gamma^{j}\mu^{j}\ \mathrm{d}\log \bar{z}_{it}^{j} + \sum_{h=1}^{J}\sum_{m=1}^{N}\Sigma_{im}^{jh}\ \mathrm{d}\log p_{imt}^{h}\ ,\text{ where } \Sigma_{im}^{jh} \equiv \gamma^{j,h}S_{imt}^{h}\ .$$

Define $\Gamma \equiv [\boldsymbol{I}-\boldsymbol{\Sigma}]^{-1}$ as the Leontief inverse of the shares Σ_{im}^{jh}. We can then write the previous equation as:

$$\mathrm{d}\log p_{nit}^{j} \quad = \quad \sum_{m=1}^{N}\sum_{o=1}^{J}\Gamma_{im}^{jo}\left\{\gamma^{o}\ \mathrm{d}\log w_{mt}^{o} - \gamma^{o}\left(\eta\mu^{o}-\alpha^{o}\right)\mathrm{d}\log \ell_{mt}^{o}\right. \tag{22}$$

$$\left. -\left(1-\mu^{o}-\alpha^{o}\right)\gamma^{o}\ \mathrm{d}\log \chi_{mt}^{o} - \mu^{o}\gamma^{o}\ \mathrm{d}\log \bar{z}_{mt}^{o}\right\}\ .$$

Expenditure Shares Totally differentiating the expenditure share equation (Equation 9), we get:

$$\frac{\mathrm{d}S_{nit}^{j}}{S_{nit}^{j}} = \theta\left(\sum_{h=1}^{N}S_{nht}^{j}\frac{\mathrm{d}p_{nht}^{j}}{p_{nht}^{j}} - \frac{\mathrm{d}p_{nit}^{j}}{p_{nit}^{j}}\right)\ .$$

$$\mathrm{d}\log S_{nit}^{j} = \theta\left(\sum_{h=1}^{N}S_{nht}^{j}\ \mathrm{d}\log p_{nht}^{j} - \mathrm{d}\log p_{nit}^{j}\right)\ . \tag{23}$$

Using the total derivatives of prices above (Equation 22), this total derivative of the expenditure shares can be written as:

$$\mathrm{d}\log S_{nit}^{j} \quad = \quad \theta\left[\sum_{h=1}^{N}S_{nht}^{j}\sum_{m=1}^{N}\sum_{o=1}^{J}\Gamma_{hm}^{jo} - \sum_{m=1}^{N}\sum_{o=1}^{J}\Gamma_{im}^{jo}\right]\times$$

$$\{\gamma^o \, \mathrm{d}\log w^o_{mt} - \gamma^o \left(\eta\mu^o - \alpha^o\right) \mathrm{d}\log \ell^o_{mt} - \left(1-\mu^o-\alpha^o\right)\gamma^o \, \mathrm{d}\log \chi^o_{mt} - \gamma^o\mu^o \, \mathrm{d}\log \bar{z}^o_{mt}\} \ .$$

Migration Shares Totally differentiating the migration share equation, we obtain:

$$\frac{\mathrm{d}D^{jh}_{igt}}{D^{jh}_{igt}} = \frac{1}{\rho}\left[\left(\beta\mathbb{E}_t \mathrm{d}v^{h,w}_{gt+1}\right) - \sum_{m=1}^{N}\sum_{o=0}^{J} D^{jo}_{imt}\left(\beta\mathbb{E}_t \, \mathrm{d}v^{o,w}_{mt+1}\right)\right] \ .$$

$$\mathrm{d}\log D^{jh}_{igt} = \frac{1}{\rho}\left[\left(\beta\mathbb{E}_t \mathrm{d}v^{h,w}_{gt+1}\right) - \sum_{m=1}^{N}\sum_{o=0}^{J} D^{jo}_{imt}\left(\beta\mathbb{E}_t \, \mathrm{d}v^{o,w}_{mt+1}\right)\right] \ .$$

Labor Payments Totally differentiating the first-order condition for labor (Equation 11) we have:

$$\mathrm{d}\log w^j_{it} + \mathrm{d}\log \ell^j_{it} = d\log y^j_{it} \ . \tag{24}$$

Note: On page 77 of their online supplement, Kleinman et al. (2023) write this equation as:

$$\mathrm{d}\log w^j_{it} + \mathrm{d}\log \ell^j_{it} = \xi^j_i \, \mathrm{d}\log y^j_{it} \ , \text{ where } \xi^j_i \equiv \frac{\gamma^j\mu^j y^j_{it}}{w^j_{it}\ell^j_{it}}.$$

But since $\xi^j_i = 1$, we omit it from our calculations, below.

Goods Market Clearing Totally differentiating the goods market clearing condition (Equation 17), we have:

$$y^j_{it} = \sum_{n=1}^{N}\sum_{h=1}^{J}\left[\left(S^j_{nit}\left[\psi^j\gamma^h + \gamma^{h,j}\right]\right) y^h_{nt}\right] \ .$$

$$\frac{\mathrm{d}y^j_{it}}{y^j_{it}} y^j_{it} = \sum_{n=1}^{N}\sum_{h=1}^{J} S^j_{nit}\left[\psi^j\gamma^h + \gamma^{h,j}\right] y^h_{nt}\frac{\mathrm{d}S^j_{nit}}{S^j_{nit}} + \sum_{n=1}^{N}\sum_{h=1}^{J}\left(S^j_{nit}\left[\psi^j\gamma^h + \gamma^{h,j}\right]\right) y^h_{nt}\frac{\mathrm{d}y^h_{nt}}{y^h_{nt}} \ .$$

which can be re-written as: Σ^{jh}_{im}

$$\mathrm{d}\log y^j_{it} = \sum_{n=1}^{N}\vartheta^j_{in} \, \mathrm{d}\log S^j_{nit} + \sum_{n=1}^{N}\sum_{h=1}^{J}\Theta^{jh}_{in} \, \mathrm{d}\log S^j_{nit} + \sum_{n=1}^{N}\vartheta^j_{in} \, \mathrm{d}\log y^h_{nt} + \sum_{n=1}^{N}\sum_{h=1}^{J}\Theta^{jh}_{in} \, \mathrm{d}\log y^n_{nt} \ , \text{where}$$

$$\vartheta^j_{in} \equiv \frac{S^j_{nit}\psi^j\sum_{h=1}^{J}\gamma^h y^h_{nt}}{y^j_{it}} \text{ and } \Theta^{jh}_{in} \equiv \frac{S^j_{nit}\gamma^{h,j}y^h_{nt}}{y^j_{it}} \ .$$

Using Equation 24, we can re-write this relationship as:

$$\begin{aligned} \mathrm{d}\log y_{it}^{j} &= \sum_{n=1}^{N} \vartheta_{in}^{j}\ \mathrm{d}\log S_{nit}^{j} + \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log S_{nit}^{j} \\ &+ \sum_{n=1}^{N}\sum_{h=1}^{J} \frac{S_{nit}^{j}\psi^{j}\gamma^{h}y_{nt}^{h}}{y_{it}^{j}} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h}\right) + \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log y_{nt}^{h}. \end{aligned}$$

We can re-write this more simply as:

$$\begin{aligned} \mathrm{d}\log y_{it}^{j} = &\sum_{n=1}^{N} \vartheta_{in}^{j}\ \mathrm{d}\log S_{nit}^{j} + \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log S_{nit}^{j} \\ &+ \sum_{n=1}^{N}\sum_{h=1}^{J} \vartheta_{in}^{jh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h}\right) + \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log y_{nt}^{h}\ , \\ \text{where } \vartheta_{in}^{jh} \equiv &\ \frac{S_{nit}^{j}\psi^{j}\gamma^{h}y_{nt}^{h}}{y_{it}^{j}}. \end{aligned}$$

$$\mathrm{d}\log y_{it}^{j} - \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log y_{nt}^{h} = \sum_{n=1}^{N}\sum_{h=1}^{J} \vartheta_{in}^{jh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h}\right) + \sum_{n=1}^{N} \left[\vartheta_{in}^{j} + \sum_{h=1}^{J} \Theta_{in}^{jh}\right] \mathrm{d}\log S_{nit}^{j}\ .$$

(Another difference with the online supplement in Kleinman et al. (2023): The left-hand-side of the previous equation is written as: $\mathrm{d}\log y_{it}^{j}\left[1 - \sum_{n=1}^{N}\sum_{h=1}^{J} \Theta_{in}^{jh}\ \mathrm{d}\log y_{nt}^{h}\right]$. This is an inconsequential typo.)

Taking the Leontief inverse of Θ_{in}^{jh}, which we denote by a matrix with entries given by Δ_{im}^{jo}, we have:

$$\mathrm{d}\log y_{it}^{j} = \sum_{m=1}^{N}\sum_{o=1}^{J} \Delta_{im}^{jo} \left[\sum_{n=1}^{N}\sum_{h=1}^{J} \vartheta_{mn}^{oh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h}\right) + \sum_{n=1}^{N} \left[\vartheta_{mn}^{o} + \sum_{h=1}^{J} \Theta_{mn}^{oh}\right] \mathrm{d}\log S_{nmt}^{o}\right]$$

Using Equation 24, this becomes:

$$\mathrm{d}\log w_{it}^{j} + \mathrm{d}\log \ell_{it}^{j} = \sum_{m=1}^{N}\sum_{o=1}^{J} \Delta_{im}^{jo} \left[\sum_{n=1}^{N}\sum_{h=1}^{J} \vartheta_{mn}^{oh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h}\right) + \sum_{n=1}^{N} \left[\vartheta_{mn}^{o} + \sum_{h=1}^{J} \Theta_{mn}^{oh}\right] \mathrm{d}\log S_{nmt}^{o}\right]\ .$$

Population Flow Totally differentiating the population flow condition we have:

$$\begin{aligned} \mathrm{d}\log \ell_{gt+1}^{h} &= \sum_{i=1}^{N}\sum_{j=0}^{J} E_{git}^{hj} \left[\ \mathrm{d}\log \ell_{it}^{j} + \mathrm{d}\log D_{igt}^{jh}\right]\ . \\ \mathrm{d}\log \ell_{gt+1}^{h} &= \sum_{i=1}^{N}\sum_{j=0}^{J} E_{git}^{hj} \left[\ \mathrm{d}\log \ell_{it}^{j} + \frac{\beta}{\rho}\left(\mathbb{E}_t \mathrm{d}v_{gt+1}^{h} - \sum_{m=1}^{N}\sum_{o=0}^{J} D_{imt}^{jo}\mathbb{E}_t\ \mathrm{d}v_{m,t+1}^{o}\right)\right]\ . \end{aligned}$$

Value Function Note that the value function can be re-written using the following results:

$$v_{it}^{j,w} = \log \left[\frac{w_{it}^j}{\prod_{o=1}^J \left[\sum_{m=1}^N p_{imt}^{-\theta}\right]^{-\psi^o/\theta}} \right] + \log b_i^j$$
$$+ \rho \log \left[\sum_{g=1}^N \sum_{h=0}^J \left(\frac{\exp\left(\beta \mathbb{E}_t v_{g,t+1}^{h,w}\right)}{\kappa_{gi}^{hj}} \right)^{1/\rho} \right] \text{ for } j > 0$$
$$= \log b_i^j + \rho \log \left[\sum_{g=1}^N \sum_{h=0}^J \left(\frac{\exp\left(\beta \mathbb{E}_t v_{g,t+1}^{h,w}\right)}{\kappa_{gi}^{hj}} \right)^{1/\rho} \right] \text{ for } j = 0 \ .$$

Note that we may re-write the following terms:

$$\prod_{o=1}^J \left[\sum_{m=1}^N (p_{imt}^o)^{-\theta} \right]^{-\psi^o/\theta} = \prod_{o=1}^J \left(\frac{(p_{iit}^o)^{-\theta}}{S_{iit}^o} \right)^{-\psi^o/\theta} .$$
$$\sum_{g=1}^N \sum_{h=0}^J \left(\exp\left(\beta \mathbb{E}_t v_{g,t+1}^{h,w}\right) / \kappa_{gi}^{hj} \right)^{1/\rho} = \frac{\left(\exp\left(\beta \mathbb{E}_t v_{i,t+1}^{j,w}\right) / \kappa_{ii}^{jj} \right)^{1/\rho}}{D_{iit}^{jj}}, \quad \kappa_{ii}^{jj} = 1 \ .$$

Plugging these into the worker's value function yields:

$$v_{it}^{j,w} = \log b_i^j + \log w_{it}^j + \sum_{o=1}^J \psi^o \left[-\frac{1}{\theta} \log S_{iit}^o - \log p_{iit}^o \right]$$
$$+ \beta \mathbb{E}_t v_{i,t+1}^{j,w} - \rho \log D_{iit}^{jj} \text{ for } j > 0 \text{ and}$$
$$= \log b_i^j + \beta \mathbb{E}_t v_{i,t+1}^{j,w} - \rho \log D_{iit}^{jj} \text{ for } j = 0 \ .$$

Totally differentiating the value function we have:

$$\mathrm{d}v_{it}^{j,w} = \mathrm{d}\log w_{it}^j + \sum_{o=1}^J \psi^o \left[-\frac{1}{\theta} \mathrm{d}\log S_{iit}^o - \mathrm{d}\log p_{iit}^o \right] + \beta \mathbb{E}_t \ \mathrm{d}v_{it+1}^{j,w} - \rho \ \mathrm{d}\log D_{iit}^{jj} \text{ for } j > 0$$
$$= \beta \mathbb{E}_t \ \mathrm{d}v_{it+1}^{j,w} - \rho \ \mathrm{d}\log D_{iit}^{jj} \text{ for } j = 0 \ .$$

Furthermore,

$$\mathrm{d}\log S_{iit}^o = -\theta \mathrm{d}\log p_{iit}^o + \theta \left[\sum_{m=1}^N S_{imt}^o \ \mathrm{d}\log p_{imt}^o \right] .$$
$$\mathrm{d}\log D_{iit}^{jj} = \frac{\beta}{\rho} \left[\mathbb{E}_t \ \mathrm{d}v_{it+1}^j - \sum_{m=1}^N \sum_{h=0}^J D_{imt}^{jh} \mathbb{E}_t v_{mt+1}^{h,w} \right] .$$

Using these results in the derivative of the value function, we have:

$$\begin{aligned}
\mathrm{d}v_{it}^{j,w} &= \mathrm{d}\log w_{it}^{j} - \sum_{o=1}^{J}\psi^{o}\sum_{m=1}^{N} S_{imt}^{o}\ \mathrm{d}\log p_{imt}^{o} + \beta\sum_{m=1}^{N}\sum_{h=0}^{J} D_{imt}^{jh}\left(\mathbb{E}_t\ \mathrm{d}v_{mt+1}^{h,w}\right)\ \text{ for } j>0\\
&= \beta\sum_{m=1}^{N}\sum_{h=0}^{J} D_{imt}^{jh}\left(\mathbb{E}_t\ \mathrm{d}v_{mt+1}^{h,w}\right)\ \text{ for } j=0.
\end{aligned}$$

From the total derivative of prices in Equation 22, we have:

$$\begin{aligned}
\mathrm{d}\log p_{imt}^{o} \quad = \quad & \sum_{n=1}^{N}\sum_{h=1}^{J}\Gamma_{mn}^{oh}\left[\gamma^{h}\ \mathrm{d}\log w_{nt}^{h} - \gamma^{h}\left(\eta\mu^{h}-\alpha^{h}\right)\mathrm{d}\log \ell_{nt}^{h}\right.\\
& \left. - \left(1-\mu^{h}-\alpha^{h}\right)\gamma^{h}\ \mathrm{d}\log\chi_{nt}^{h} - \mu^{h}\gamma^{h}\ \mathrm{d}\log\bar{z}_{nt}^{h}\right] \quad .
\end{aligned}$$

(Note that on page 80 of the online supplement of Kleinman et al., 2023, Γ_{mn}^{oh} is written as Γ_{mz}^{oh}. This is an inconsequential typo.)

Using this result in the value function above, we obtain:

$$\begin{aligned}
\mathrm{d}v_{it}^{j,w} &= \mathrm{d}\log w_{it}^{j} - \sum_{o=1}^{J}\sum_{m=1}^{N}\psi^{o}S_{imt}^{o}\sum_{n=1}^{N}\sum_{h=1}^{J}\Gamma_{mn}^{oh}\left[\gamma^{h}\mathrm{d}\log w_{nt}^{h} - \gamma^{h}\left(\mu^{h}\eta-\alpha^{h}\right)\mathrm{d}\log\ell_{nt}^{h}\right.\\
&\quad \left. - \left(1-\mu^{h}-\alpha^{h}\right)\gamma^{h}\mathrm{d}\log\chi_{nt}^{h} - \mu^{h}\gamma^{h}\ \mathrm{d}\log\bar{z}_{nt}^{h}\right] + \beta\sum_{m=1}^{N}\sum_{h=0}^{J} D_{imt}^{jh}\mathbb{E}_{\mathrm{t}}\ \mathrm{d}v_{mt+1}^{h,w}\ \text{ for } j>0 \text{ and}\\
&= \beta\sum_{m=1}^{N}\sum_{h=0}^{J} D_{imt}^{jh}\left(\mathbb{E}_{\mathrm{t}}\ \mathrm{d}v_{mt+1}^{h,w}\right)\ \text{ for } j=0.
\end{aligned}$$

E.1.8 Steady State

Suppose that the economy starts from an initial steady-state with constant values of the endogenous variables: $k_{it+1}^{j} = k_{it}^{j} = k_{i}^{j*}, \ell_{it+1}^{j} = \ell_{it}^{j} = \ell_{i}^{j*}, w_{it+1}^{j*} = w_{it}^{j*} = w_{i}^{j*}$ and $v_{it+1}^{j*} = v_{it}^{j*} = v_{i}^{j*}$ where we use an asterisk to denote a steady-state value. We consider small common shocks to productivity across sector-locations ($\mathrm{d}\log\boldsymbol{z}$) and to the capital wedges in these sector-location combinations ($\mathrm{d}\log\tau^{K}$).

Capital Accumulation From the capital accumulation equation (Equation 16), the steady-state stock of equipment capital solves:

$$\mathcal{K}_{i}^{j*} = \beta\left[\Sigma_{im}^{jh}\frac{\sum_{h=1}^{J}\sum_{n=1}^{N}\frac{\phi_{ij\to nh}r_{n}^{h*}}{\tau_{nh}^{K*}}}{P_{i}} + (1-\delta)\right]\mathcal{K}_{i}^{j*}\ .$$

$$\left(1-\beta\left(1-\delta\right)\right)\mathcal{K}_{i}^{j*} = \beta\frac{\sum_{h=1}^{J}\sum_{n=1}^{N}\frac{\phi_{ij\to nh}r_{n}^{h*}}{\tau_{nh}^{K*}}}{P_{i}^{*}}\mathcal{K}_{i}^{j*}\ .$$

Using the relationship between labor and capital payments (Equations 11 and 12), we have:

$$r_n^{h*} = \frac{1-\mu^h-\alpha^h}{\mu^h}\frac{w_n^{h*}\ell_n^{h*}}{k_n^{h*}} \ .$$

Using this result in the expression for the steady-state capital stock above, we have:

$$\left(\frac{1}{\beta}-(1-\delta)\right)P_i^* = \sum_{h=1}^{J}\sum_{n=1}^{N}\phi_{ij\to nh}\frac{1-\mu^h-\alpha^h}{\mu^h}\frac{w_n^{h*}}{\chi_n^{h*}\tau_{nh}^{K*}} \ .$$

We can write the above in matrix form:

$$\mathrm{d}\log \boldsymbol{P}^* = \hat{\Phi}\mathrm{d}\log \boldsymbol{w}^* - \hat{\Phi}\mathrm{d}\log \boldsymbol{\tau}^K - \hat{\Phi}\mathrm{d}\log \boldsymbol{\chi}^* \ . \tag{25}$$

Here $\boldsymbol{P}^*$ is a $N\cdot J$ by 1 dimensional vector, with entries equal to P_i^* for entries corresponding to region i. Also $\hat{\Phi}$ is a matrix that has $\frac{\phi_{ij\to nh}\frac{1-\mu^h-\alpha^h}{\mu^h}}{\sum_{n',h'}\phi_{ij\to n'h'}\frac{1-\mu^{h'}-\alpha^{h'}}{\mu^{h'}}}$ in row ij and column nh.

We now derive an expression for the total derivative of real income:

$$\mathrm{d}\log\left(\frac{w_i^{j*}}{P_i^*}\right) = \mathrm{d}\log w_i^{j*} - \mathrm{d}\log P_i^* \ .$$

The total derivative of the aggregate price index (Equation 6) is given by:

$$\mathrm{d}\log P_i^* = \sum_{h=1}^{J}\psi^h \mathrm{d}\log p_i^{h*} = \sum_{h=1}^{J}\sum_{m=1}^{N}\psi^h S_{im}^{h*}\ \mathrm{d}\log p_{im}^{h*} \ .$$

Using our expression for the total derivative of prices above, we can re-write this total derivative of the aggregate price index as:

$$\begin{aligned}\mathrm{d}\log P_i^* \quad = \quad & \sum_{m=1}^{N}\sum_{h=1}^{J}\psi^h S_{im}^{h*}\sum_{n=1}^{N}\sum_{o=1}^{J}\Gamma_{mn}^{ho}\left[\gamma^o\ \mathrm{d}\log w_n^{o*} - \gamma^o\left(\eta\mu^o-\alpha^o\right)\mathrm{d}\log \ell_n^{o*}\right.\\ & \left.-\mu^o\gamma^o\ \mathrm{d}\log \bar{z}_n^{o*} - \left(1-\mu^o-\alpha^o\right)\gamma^o\ \mathrm{d}\log \chi_n^{o*}\right] \ .\end{aligned}$$

We can write this in matrix form:

$$\mathrm{d}\log \boldsymbol{P}^* = \tilde{\boldsymbol{S}}\left(\mathrm{d}\log \boldsymbol{w}^* - \left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\mathrm{d}\log \boldsymbol{l}^* - \boldsymbol{\mu}\mathrm{d}\log \bar{\mathbf{z}} - (\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\mathrm{d}\log \boldsymbol{\chi}^*\right) \ .$$

Using these results in the equation linking changes in the aggregate price index (Equation 25), the change the steady-state capital labor ratio is given by the matrix representation:

$$\mathrm{d}\log \boldsymbol{\chi}^* = \mathrm{d}\log \boldsymbol{w}^* - \mathrm{d}\log \boldsymbol{\tau}^K - \hat{\Phi}^{-1}\tilde{\boldsymbol{S}}\left(\mathrm{d}\log \boldsymbol{w}^* - \left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\mathrm{d}\log \boldsymbol{l}^* - \boldsymbol{\mu}\mathrm{d}\log \bar{\mathbf{z}} - (\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\mathrm{d}\log \boldsymbol{\chi}^*\right) \ .$$

where $\mathrm{d}\log \boldsymbol{\chi}^*$, $\mathrm{d}\log \boldsymbol{l}^*$,$\mathrm{d}\log \bar{\mathbf{z}}$, $\mathrm{d}\log \boldsymbol{\tau}^K$, and $\mathrm{d}\log \boldsymbol{w}^*$ are $NJ\times 1$ vectors; $(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})$, $\boldsymbol{\mu}$, and $\boldsymbol{\alpha}$ are $NJ\times NJ$ diagonal matrices with, respectively, $1-\mu^j-\alpha^j$, μ^j, and α^j in entries corresponding to industry j; and $\tilde{\boldsymbol{S}}$ is a $NJ\times NJ$ matrix with elements:

$$\tilde{\boldsymbol{S}}_{in}^{o*} = \sum_{m=1}^{N}\sum_{h=1}^{J}\psi^h S_{im}^{h*}\Gamma_{mn}^{ho}\gamma^o \ .$$

(Note this definition is somewhat different to what appears on the final line of page 81 of the supplemental appendix of Kleinman et al. (2023). We also include a $\widetilde{\cdot}$ to distinguish between this new matrix and the existing expenditure shares.)

Goods Market Clearing Recall that the total derivative of the expenditure share equation is:

$$\begin{aligned} \mathrm{d}\log S_{nit}^{j} \;=\; & \theta \left[\sum_{h=1}^{N} S_{nht}^{j} \sum_{m=1}^{N} \sum_{o=1}^{J} \Gamma_{hm}^{jo} - \sum_{m=1}^{N} \sum_{o=1}^{J} \Gamma_{im}^{jo} \right] \times \\ & \left[\gamma^{o}\, \mathrm{d}\log w_{mt}^{o} - \gamma^{o} \left(\mu^{o}\eta - \alpha^{o} \right) \mathrm{d}\log \ell_{mt}^{o} - \left(1 - \mu^{o} - \alpha^{o} \right) \gamma^{o}\, \mathrm{d}\log \chi_{mt}^{o} - \mu^{o}\gamma^{o}\, \mathrm{d}\log \bar{z}_{mt}^{o} \right] . \end{aligned}$$

We can re-write this total derivative of the expenditure share as:

$$\begin{aligned} \mathrm{d}\log S_{nmt}^{j} = & \theta \left[\sum_{h=1}^{N} S_{nht}^{j} \sum_{g=1}^{N} \sum_{o=1}^{J} \Lambda_{hg}^{jo} - \sum_{g=1}^{N} \sum_{o=1}^{J} \Lambda_{mg}^{jo} \right] \times \\ & \left[\mathrm{d}\log w_{gt}^{o} - \left(1 - \mu^{o} - \alpha^{o} \right) \mathrm{d}\log \chi_{gt}^{o} - \mu^{o} \mathrm{d}\log \bar{z}_{gt}^{o} - \left(\mu^{o}\eta - \alpha^{o} \right) \mathrm{d}\log \ell_{gt}^{o} \right] , \end{aligned}$$

where $\Upsilon_{hg}^{jo} \equiv \gamma^{o} \Gamma_{hg}^{jo}$.

$$\mathrm{d}\log w_{it}^{j} + \mathrm{d}\log \ell_{it}^{j} = \sum_{m=1}^{N} \sum_{o=1}^{J} \Delta_{im}^{jo} \left[\sum_{n=1}^{N} \sum_{h=1}^{J} \vartheta_{mn}^{oh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h} \right) + \sum_{n=1}^{N} \left[\vartheta_{mn}^{o} + \sum_{h=1}^{J} \Theta_{mn}^{oh} \right] \mathrm{d}\log S_{nmt}^{o} \right] .$$

Recall that the total derivative of the goods market clearing condition is:

$$\begin{aligned} \mathrm{d}\log w_{it}^{j} + \mathrm{d}\log \ell_{it}^{j} \;=\; & \sum_{m=1}^{N} \sum_{o=1}^{J} \Delta_{im}^{jo} \left[\sum_{n=1}^{N} \sum_{h=1}^{J} \vartheta_{mn}^{oh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h} \right) \right. \\ & \left. + \sum_{n=1}^{N} \left[\vartheta_{mn}^{o} + \sum_{h=1}^{J} \Theta_{mn}^{oh} \right] \mathrm{d}\log S_{nmt}^{o} \right] . \end{aligned}$$

Using this expression for the total derivative of the expenditure share in the total derivative of the goods market clearing condition in equation, we obtain:

$$\begin{aligned} \mathrm{d}\log w_{it}^{j} + \mathrm{d}\log \ell_{it}^{j} \;=\; & \sum_{m=1}^{N} \sum_{o=1}^{J} \Delta_{im}^{jo} \sum_{n=1}^{N} \sum_{h=1}^{J} \vartheta_{mn}^{oh} \left(\mathrm{d}\log w_{nt}^{h} + \mathrm{d}\log \ell_{nt}^{h} \right) + \\ & \sum_{m=1}^{N} \sum_{o=1}^{J} \Delta_{im}^{jo} \theta \sum_{n=1}^{N} \left[\vartheta_{mn}^{o} + \sum_{h=1}^{J} \Theta_{mn}^{oh} \right] \times \left\{ \sum_{g=1}^{N} \left[\sum_{z=1}^{N} S_{nzt}^{o} \sum_{q=1}^{J} \Upsilon_{zg}^{oq} - \sum_{q=1}^{J} \Upsilon_{mg}^{oq} \right] \right. \\ & \left. \times \left[\mathrm{d}\log w_{gt}^{q} - \mu^{q} \mathrm{d}\log \bar{z}_{gt}^{q} - \left(\mu^{q}\eta - \alpha^{q} \right) \mathrm{d}\log \ell_{gt}^{q} - \left(1 - \mu^{q} - \alpha^{q} \right) \mathrm{d}\log \chi_{gt}^{q} \right] \right\} . \end{aligned}$$

We can write this goods market clearing condition in matrix form as:

$$\begin{aligned} \mathrm{d}\log \boldsymbol{w_t} + \mathrm{d}\log \boldsymbol{l_t} \;=\; & \boldsymbol{T} \left(\mathrm{d}\log \boldsymbol{w}_t + \mathrm{d}\log \boldsymbol{l}_t \right) \\ & + \theta \boldsymbol{M} \left(\mathrm{d}\log \boldsymbol{w}_t - \left(\boldsymbol{\mu}\eta - \boldsymbol{\alpha} \right) \mathrm{d}\log \boldsymbol{l}_t - \boldsymbol{\mu} \mathrm{d}\log \bar{\boldsymbol{z}}_t - (\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha}) \mathrm{d}\log \boldsymbol{\chi}_t \right) , \end{aligned}$$

where these matrices have $NJ \times NJ$ elements. In particular, $\boldsymbol{T}$ is a $NJ \times NJ$ matrix with elements:

$$T_{in}^{jh} = \sum_{m=1}^{N}\sum_{o=1}^{J}\Delta_{im}^{jo}\vartheta_{mn}^{oh} \ ,$$

and $\boldsymbol{M}$ is a $NJ \times NJ$ matrix with elements:

$$M_{ig}^{jq} = \sum_{o=1}^{J}\sum_{m=1}^{N}\Delta_{im}^{jo}\sum_{n=1}^{N}\left[\vartheta_{mn}^{o} + \sum_{h=1}^{J}\Theta_{mn}^{oh}\right]\left\{\left[\sum_{z=1}^{N}S_{nzt}^{o}\Upsilon_{zg}^{oq}\right] - \Upsilon_{mg}^{oq}\right\} \ .$$

(Note the definition of the $\boldsymbol{T}$ and $\boldsymbol{M}$ matrices are somewhat different to what appears on the final line of page 82 and the top line of page 83 of the supplemental appendix of Kleinman et al., 2023.)

In steady-state we have:

$$\begin{aligned} \mathrm{d}\log\boldsymbol{w}^* + \mathrm{d}\log\boldsymbol{l}^* \quad &= \quad \boldsymbol{T}\left(\mathrm{d}\log\boldsymbol{w}^* + \mathrm{d}\log\boldsymbol{l}^*\right) \\ &\quad +\theta\boldsymbol{M}\left(\mathrm{d}\log\boldsymbol{w}^* - (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\,\mathrm{d}\log\boldsymbol{l}^* - \boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}} - (\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\mathrm{d}\log\boldsymbol{\chi}^*\right) \ . \end{aligned}$$

Population Flow The total derivative of the population flow condition has the following matrix representation:

$$\mathrm{d}\log\boldsymbol{l}_{t+1} = \boldsymbol{E}\mathrm{d}\log\boldsymbol{l_t} + \frac{\beta}{\rho}(\boldsymbol{I} - \boldsymbol{ED})\mathbb{E}_t\mathrm{d}\boldsymbol{v}_{t+\mathbf{1}} \ ,$$

where these matrices again have $NJ \times NJ$ elements. In steady-state, we have:

$$\mathrm{d}\log\boldsymbol{l}^* = \frac{\beta}{\rho}(\boldsymbol{I} - \boldsymbol{E})^{-1}(\boldsymbol{I} - \boldsymbol{ED})\mathrm{d}\boldsymbol{v}^* \ .$$

Value function Recall from before that the total derivative of the value function is given by:

$$\begin{aligned} \mathrm{d}v_{it}^{j,w} \quad = \quad & \mathbf{1}_{j>0}\cdot\{\mathrm{d}\log w_{it}^{j} - \sum_{o=1}^{J}\sum_{m=1}^{N}\psi^{o}S_{imt}^{o}\sum_{n=1}^{N}\sum_{h=1}^{J}\Gamma_{mn}^{oh}[\gamma^{h}\ \mathrm{d}\log w_{nt}^{h} \\ & -\gamma^{h}\left(\eta\mu^{h} - \alpha^{h}\right)\mathrm{d}\log\ell_{nt}^{h} - \mu^{h}\gamma^{h}\ \mathrm{d}\log\bar{z}_{nt}^{h} \\ & -\left(1 - \mu^{h} - \alpha^{h}\right)\gamma^{h}\mathrm{d}\log\chi_{nt}^{h}]\} + \beta\sum_{m=1}^{N}\sum_{h=0}^{J}D_{imt}^{jh}\left(\mathbb{E}_t\ \mathrm{d}v_{m,t+1}^{h,w}\right) \ . \end{aligned}$$

Recall that the matrix $\tilde{\boldsymbol{S}}$ has elements S_{int}^{j} given by:

$$\tilde{\boldsymbol{S}}_{in}^{j*} = \sum_{m=1}^{N}\sum_{h=1}^{J}\psi^{h}S_{im}^{h*}\Gamma_{mn}^{hj}\gamma^{j} \ .$$

In steady-state, this total derivative of the value function has the following matrix representation:

$$\mathrm{d}\boldsymbol{v}^* = (\boldsymbol{I}{-}\beta\boldsymbol{D})^{-1}\left[\mathbf{1}_{j>0}(\boldsymbol{I} - \tilde{\boldsymbol{S}})\mathrm{d}\log\boldsymbol{w}^* + \mathbf{1}_{j>0}\tilde{\boldsymbol{S}}\left(\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}} + (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\,\mathrm{d}\log\boldsymbol{l}^* + (\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\mathrm{d}\log\boldsymbol{\chi}^*\right)\right] \ .$$

System of Steady-State Equations Collecting the system of steady-state equations, we have:

$$
\begin{aligned}
\mathrm{d}\log\boldsymbol{\chi}^* &= \left(\boldsymbol{I}-\hat{\Phi}^{-1}\tilde{\boldsymbol{S}}\right)\mathrm{d}\log\boldsymbol{w}^* - \mathrm{d}\log\boldsymbol{\tau}^K \\
&\quad + \hat{\Phi}^{-1}\tilde{\boldsymbol{S}}\left(\boldsymbol{\mu}\eta - \boldsymbol{\alpha}\right)\mathrm{d}\ln\boldsymbol{l}^* + \hat{\Phi}^{-1}\tilde{\boldsymbol{S}}\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}} + \hat{\Phi}^{-1}\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\mathrm{d}\log\boldsymbol{\chi}^* \\
\mathrm{d}\log\boldsymbol{w}^* + \mathrm{d}\log\boldsymbol{l}^* &= \boldsymbol{T}\left(\mathrm{d}\log\boldsymbol{w}^* + \mathrm{d}\log\boldsymbol{l}^*\right) \\
&\quad + \theta\boldsymbol{M}\left(\mathrm{d}\log\boldsymbol{w}^* - \left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\mathrm{d}\log\boldsymbol{l}^* - \boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}} - (\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\mathrm{d}\log\boldsymbol{\chi}^*\right) \\
\mathrm{d}\log\boldsymbol{l}^* &= \frac{\beta}{\rho}(\boldsymbol{I}-\boldsymbol{E})^{-1}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})\mathrm{d}\boldsymbol{v}^* \\
\mathrm{d}\boldsymbol{v}^* &= (\boldsymbol{I}-\beta\boldsymbol{D})^{-1}\cdot \\
&\quad \mathbf{1}_{j>0}\left\{(\boldsymbol{I}-\tilde{\boldsymbol{S}})\mathrm{d}\log\boldsymbol{w}^* + \tilde{\boldsymbol{S}}\left(\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}} + \left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\mathrm{d}\log\boldsymbol{l}^* + (\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\mathrm{d}\log\boldsymbol{\chi}^*\right)\right\} .
\end{aligned}
$$

E.1.9 Transition Dynamics

Suppose that the economy starts from an initial steady-state. Consider a small shock to productivity $\mathrm{d}\log\boldsymbol{z}$ and to capital wedges $\mathrm{d}\log\boldsymbol{\tau}^K$ in each location, holding constant the economy's aggregate labor endowment, trade costs, migration costs, and amenities. For endogenous variables, we use a tilde above a variable to denote a log deviation from the initial steady-state, such that $\tilde{\ell}_{it+1} = \ell_{it+1} - \ell_i^*$, for all variables except for the worker value function v_{it}, where with a slight abuse of notation we use $\widetilde{v}_{it} = v_{it} - v_t^*$ to denote the deviation in levels for the worker value function.

Capital Accumulation $\left(1-\beta\left(1-\delta\right)\right) = \beta\frac{\sum_{h=1}^{J}\sum_{n=1}^{N}\frac{\phi_{ij\to nh}r_n^{h*}}{\tau_{nh}^{K*}}}{P_i^*}$.

From the capital accumulation equation, we have:

$$
\mathcal{K}_{i,t+1}^j = \beta\frac{\sum_{n=1}^N \phi_{ij\to nj}\frac{r_{nt}^j}{\tau_{nj,t}^K}}{P_{it}}\mathcal{K}_{it}^j + \beta\left(1-\delta\right)\mathcal{K}_{it}^j \text{ for } j>0 .
$$

Note, here, we use our assumption that capital investors only hold capital in the industry they are denominated in.

From the relationship between labor and capital payments, we have:

$$
\sum_{n=1}^N \phi_{ij\to nj}\frac{r_{nt}^j}{\tau_{nj,t}^K} = \sum_{n=1}^N \phi_{ij\to nj}\frac{1-\mu^j-\alpha^j}{\mu^j}\frac{w_{nt}^j\ell_{nt}^j}{\tau_{nj,t}^K k_{nt}^j} .
$$

Plugging this result in the capital accumulation equation we have (for $j>0$):

$$
\mathcal{K}_{i,t+1}^j = \beta\frac{\sum_{n=1}^N \phi_{ij\to nj}\frac{1-\mu^j-\alpha^j}{\mu^j}\frac{w_{nt}^j\ell_{nt}^j}{\tau_{nj,t}^K k_{nt}^j}}{P_{it}/P_i^*}\frac{1}{P_i^*}\mathcal{K}_{it}^j + \beta\left(1-\delta\right)\mathcal{K}_{it}^j ,
$$

while in steady state we have:

$$\left[\frac{1}{\beta}-(1-\delta)\right]\cdot\frac{1}{\sum_{n=1}^{N}\phi_{ij\to nj}\frac{1-\mu^j-\alpha^j}{\mu^j}\frac{w_n^{j*}}{\tau_{nj}^{K*}\chi_n^{j*}}}=\frac{1}{P_i^*}\text{ for }j>0\ .$$

Combining these expressions:

$$\mathcal{K}_{i,t+1}^j=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n=1}^{N}\frac{\phi_{ij\to nj}\frac{1-\mu^j-\alpha^j}{\mu^j}\frac{w_n^{j*}}{\tau_{nj}^{K*}\chi_n^{j*}}}{\sum_{n'=1}^{N}\phi_{ij\to n'j}\left(\frac{1-\mu^j-\alpha^j}{\mu^j}\frac{w_{n'}^{j*}}{\tau_{n'j,t}^{K}\chi_{n'}^{j*}}\right)}\frac{w_{nt}^j/w_n^{j*}}{\frac{\tau_{nj,t}^K}{\tau_{nj}^{K*}}\frac{\chi_{nt}^j}{\chi_n^{j*}}}\right]\frac{P_i^*}{P_{it}}\mathcal{K}_{it}^j+\beta\left(1-\delta\right)\mathcal{K}_{it}^j$$

$$=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n=1}^{N}\underbrace{\frac{\phi_{ij\to nj}\cdot r_{nj}^*}{\tau_{nj}^{K*}\cdot\mathcal{R}_i^{j*}}}_{\equiv\tilde{\lambda}_{ij\to nh}}\frac{w_{nt}^j/w_n^{j*}}{\frac{\tau_{nj,t}^K}{\tau_{nj}^{K*}}\frac{\chi_{nt}^j}{\chi_n^{j*}}}\right]\frac{P_i^*}{P_{it}}\mathcal{K}_{it}^j+\beta\left(1-\delta\right)\mathcal{K}_{it}^j$$

$$=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n=1}^{N}\tilde{\lambda}_{ij\to nj}\frac{w_{nt}^j/w_n^{j*}}{\frac{\tau_{nj,t}^K}{\tau_{nj}^{K*}}\frac{\chi_{nt}^j}{\chi_n^{j*}}}\right]\frac{P_i^*}{P_{it}}\mathcal{K}_{it}^j+\beta\left(1-\delta\right)\mathcal{K}_{it}^j\ .$$

Multiplying by the share of capital holdings for each investor, then summing across source markets:

$$\phi_{ij\to nj}\mathcal{K}_{i,t+1}^j=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\tilde{\lambda}_{ij\to n'j}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\right]\frac{P_i^*}{P_{it}}\phi_{ij\to nj}\mathcal{K}_{it}^j+\beta\left(1-\delta\right)\phi_{ij\to nj}\mathcal{K}_{it}^j$$

$$\sum_{i=1}^{N}\phi_{ij\to nj}\mathcal{K}_{i,t+1}^j=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\sum_{i=1}^{N}\frac{P_i^*}{P_{it}}\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}\mathcal{K}_{it}^j\right]+\beta\left(1-\delta\right)\sum_{i=1}^{N}\phi_{ij\to nj}\mathcal{K}_{it}^j$$

$$\frac{k_{n,t+1}^j}{k_n^{j*}}=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\sum_{i=1}^{N}\frac{P_i^*}{P_{it}}\frac{\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}\mathcal{K}_{it}^j}{k_{nt}^j}\right]\frac{k_{nt}^j}{k_n^{j*}}+\beta\left(1-\delta\right)\frac{k_{nt}^j}{k_n^{j*}}$$

$$=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\sum_{i=1}^{N}\frac{P_i^*}{P_{it}}\tilde{\lambda}_{ij\to n'j}\frac{\phi_{ij\to nj}\mathcal{K}_{it}^j}{\sum_{i'=1}^{N}\phi_{i'j\to nj}\mathcal{K}_{i't}^j}\right]\frac{k_{nt}^j}{k_n^{j*}}+\beta\left(1-\delta\right)\frac{k_{nt}^j}{k_n^{j*}}$$

$$=\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\sum_{i=1}^{N}\frac{P_i^*}{P_{it}}\tilde{\lambda}_{ij\to n'j}\frac{\phi_{ij\to nj}}{\sum_{i'=1}^{N}\phi_{i'j\to nj}\mathcal{K}_{i't}^j/\mathcal{K}_{it}^j}\right]\frac{k_{nt}^j}{k_n^{j*}}+\beta\left(1-\delta\right)\frac{k_{nt}^j}{k_n^{j*}}$$

$$\approx\left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\sum_{i=1}^{N}\frac{w_{n't}^j/w_{n'}^{j*}}{\frac{\tau_{n'j,t}^K}{\tau_{n'j}^{K*}}\frac{\chi_{n't}^j}{\chi_{n'}^{j*}}}\frac{P_i^*}{P_{it}}\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}\right]\frac{k_{nt}^j}{k_n^{j*}}+\beta\left(1-\delta\right)\frac{k_{nt}^j}{k_n^{j*}}\ .$$

Then:

$$\frac{k^j_{n,t+1}/k^{j*}_n}{\ell^j_{n,t+1}/\ell^{j*}_n}\frac{\ell^j_{n,t+1}/\ell^{j*}_n}{\ell^j_{nt}/\ell^{j*}_n} \approx \left[1-\beta\left(1-\delta\right)\right]\left[\sum_{n'=1}^{N}\sum_{i=1}^{N}\frac{w^j_{n't}/w^{j*}_{n'}}{\frac{\tau^K_{n'j,t}}{\tau^{K*}_{n'j}}\frac{\chi^j_{n't}}{\chi^{j*}_{n'}}}\frac{P^*_i}{P_{it}}\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}\right]\frac{k^j_{n,t}/k^{j*}_n}{\ell^j_{nt}/\ell^{j*}_n}+\beta\left(1-\delta\right)\frac{k^j_{n,t}/k^{j*}_n}{\ell^j_{nt}/\ell^{j*}_n}$$

$$\frac{\chi^j_{n,t+1}}{\chi^{j*}_n}\frac{\ell^j_{n,t+1}/\ell^{j*}_i}{\ell^j_{nt}/\ell^{j*}_i} \approx \left[1-\beta\left(1-\delta\right)\right]\cdot\left[\sum_{n'=1}^{N}\sum_{i=1}^{N}\frac{w^j_{n't}/w^{j*}_{n'}}{\frac{\tau^K_{n'j,t}}{\tau^{K*}_{n'j}}\frac{\chi^j_{n't}}{\chi^{j*}_{n'}}}\frac{P^*_i}{P_{it}}\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}\right]\frac{\chi^j_{n,t}}{\chi^{j*}_n}+\beta\left(1-\delta\right)\frac{\chi^j_{n,t}}{\chi^{j*}_n}\ .$$

In matrix form this can be written as:

$$\begin{aligned}\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+1}} &= \tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} - \Xi(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\tilde{\boldsymbol{P}}_t + (\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\Omega\left(\tilde{\boldsymbol{w}}_t - \tilde{\boldsymbol{\chi}}_t - \mathrm{d}\log\boldsymbol{\tau}^{\boldsymbol{K}}_{\boldsymbol{t}}\right)\\ &\quad - \tilde{\boldsymbol{\ell}}_{\boldsymbol{t+1}} + \tilde{\boldsymbol{\ell}}_t \text{ for } j>0, \text{ and}\\ &= -\tilde{\boldsymbol{\ell}}_{\boldsymbol{t+1}} \text{ for } j=0\ .\end{aligned}$$

Here, Ξ is a block diagonal (with non-zero entries only in columns and rows associated with the same industry) NJ by NJ matrix that has entries $\phi_{ij\to nj}\sum_{n'=1}^{N}\tilde{\lambda}_{ij\to n'j}=\phi_{ij\to nj}$ in columns associated with region i and rows associated with region n (and industry j).

Furthermore Ω is a block diagonal (with non-zero entries only in columns and rows associated with the same industry) NJ by NJ matrix that has entries $\sum_{i=1}^{N}\tilde{\lambda}_{ij\to n'j}\phi_{ij\to nj}$ in columns associated with region n' and rows associated with region n (and industry j).

Following an analogous analysis as for steady-state above, the total derivative of real income relative to the initial steady-state can be written in matrix form as:

$$\begin{aligned}\tilde{\boldsymbol{w}}_t - \tilde{\boldsymbol{P}}_t &= (\boldsymbol{I}-\tilde{\boldsymbol{S}})\tilde{\boldsymbol{w}}_t + \tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_t + \tilde{\boldsymbol{S}}\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t + (\eta\boldsymbol{\mu}-\boldsymbol{\alpha})\,\tilde{\boldsymbol{S}}\tilde{\boldsymbol{\ell}}_{\boldsymbol{t}}\\ \tilde{\boldsymbol{P}}_t &= \tilde{\boldsymbol{S}}\tilde{\boldsymbol{w}}_t - \tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_t - \tilde{\boldsymbol{S}}\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t - (\eta\boldsymbol{\mu}-\boldsymbol{\alpha})\,\boldsymbol{S}\tilde{\boldsymbol{\ell}}_{\boldsymbol{t}}\ .\end{aligned}$$

Using this result in our expression for the dynamics of the capital-labor ratio above, we have:

$$\begin{aligned}\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+1}} + \tilde{\boldsymbol{\ell}}_{t+1} &= \left[\boldsymbol{I} + (\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\left[\Xi\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})-\Omega\right]\right]\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}}\\ &\quad + (\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))(\Omega-\Xi\tilde{\boldsymbol{S}})\tilde{\boldsymbol{w}}_t\\ &\quad + \Xi(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\tilde{\boldsymbol{S}}\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t\\ &\quad + \left[\boldsymbol{I} + \Xi\left(\eta\boldsymbol{\mu}-\boldsymbol{\alpha}\right)(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\tilde{\boldsymbol{S}}\right]\tilde{\boldsymbol{\ell}}_t\\ &\quad - (\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\Omega\ \mathrm{d}\log\tau^K_t \text{ for } j>0, \text{ and}\\ &= 0 \text{ for } j=0\ .\end{aligned}$$

Goods Market Clearing Following an analogous analysis as for steady-state above, the total derivative of the goods market clearing condition can be written in matrix form as:

$$\tilde{\boldsymbol{w}}_t + \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} = \boldsymbol{T}\left(\tilde{\boldsymbol{w}}_t + \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}}\right) + \theta\boldsymbol{M}\left(\tilde{\boldsymbol{w}}_t - (\boldsymbol{\mu}\eta-\boldsymbol{\alpha})\,\tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} - \boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t - (\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}}\right)\ ,$$

where these matrices have $NJ \times NJ$ elements. This expression can be re-written as:

$$\widetilde{\boldsymbol{w}}_t = [\boldsymbol{I} - \boldsymbol{T} - \theta \boldsymbol{M}]^{-1} \left[-(\boldsymbol{I} - \boldsymbol{T})\tilde{\boldsymbol{\ell}}_t - \theta \boldsymbol{M} \left[(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} + \boldsymbol{\mu} \mathrm{d} \log \bar{\boldsymbol{z}}_t + (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\, \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} \right] \right] \ .$$

Population Flow The total derivative of the population flow condition relative to the initial steady-state has the following matrix representation:

$$\tilde{\boldsymbol{\ell}}_{\boldsymbol{t+1}} = \boldsymbol{E}\tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} + \frac{\beta}{\rho}(\boldsymbol{I} - \boldsymbol{E}\boldsymbol{D})\mathbb{E}_t \tilde{\boldsymbol{v}}_{t+1} \ ,$$

where again these matrices have $NJ \times NJ$ elements.

Value Function Following an analogous analysis as for steady-state above, the total derivative of the value function relative to the initial steady-state can be written in matrix form as:

$$\widetilde{\boldsymbol{v}}_t = \mathbf{1}_{j>0} \left\{ (\boldsymbol{I} - \tilde{\boldsymbol{S}})\widetilde{\boldsymbol{w}}_t + \tilde{\boldsymbol{S}} \left[(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} + (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\, \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} + \boldsymbol{\mu} \mathrm{d} \log \bar{\boldsymbol{z}}_t \right] \right\} + \beta \boldsymbol{D} \mathbb{E}_t \tilde{\boldsymbol{v}}_{t+1} \ ,$$

where again these matrices have $NJ \times NJ$ elements.

System of Equations Collecting together the system of equations for the transition dynamics, we have:

$$\begin{aligned} \tilde{\boldsymbol{\chi}}_{\boldsymbol{t+1}} + \tilde{\boldsymbol{\ell}}_{t+1} = \mathbf{1}_{j>0} \Big\{ & \Big[\boldsymbol{I} + (\boldsymbol{I} - \beta(\boldsymbol{I} - \boldsymbol{\delta})) \left[\Xi \tilde{\boldsymbol{S}}(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha}) - \boldsymbol{\Omega} \right] \Big] \tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} \\ & + (\boldsymbol{I} - \beta(\boldsymbol{I} - \boldsymbol{\delta}))(\boldsymbol{\Omega} - \Xi \tilde{\boldsymbol{S}})\tilde{\boldsymbol{w}}_t \\ & + \Xi(\boldsymbol{I} - \beta(\boldsymbol{I} - \boldsymbol{\delta}))\tilde{\boldsymbol{S}}\boldsymbol{\mu} \mathrm{d} \log \bar{\boldsymbol{z}}_t \\ & + \left[\boldsymbol{I} + \Xi\, (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\, (\boldsymbol{I} - \beta(\boldsymbol{I} - \boldsymbol{\delta}))\tilde{\boldsymbol{S}} \right] \tilde{\boldsymbol{\ell}}_t \\ & - (\boldsymbol{I} - \beta(\boldsymbol{I} - \boldsymbol{\delta}))\boldsymbol{\Omega}\ \mathrm{d} \log \boldsymbol{\tau}_t^K] \Big\} \ . \end{aligned} \tag{26}$$

$$\widetilde{\boldsymbol{w}}_t = \mathbf{1}_{j>0}[\boldsymbol{I} - \boldsymbol{T} - \theta \boldsymbol{M}]^{-1} \left[-(\boldsymbol{I} - \boldsymbol{T})\tilde{\boldsymbol{\ell}}_t - \theta \boldsymbol{M} \left[(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} + \boldsymbol{\mu} \mathrm{d} \log \bar{z}_t + (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\, \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} \right] \right] \ . \tag{27}$$

$$\tilde{\boldsymbol{\ell}}_{\boldsymbol{t+1}} = \boldsymbol{E}\tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} + \frac{\beta}{\rho}(\boldsymbol{I} - \boldsymbol{E}\boldsymbol{D})\mathbb{E}_t \tilde{\boldsymbol{v}}_{t+1} \ . \tag{28}$$

$$\widetilde{\boldsymbol{v}}_t = \mathbf{1}_{j>0} \left\{ (\boldsymbol{I} - \tilde{\boldsymbol{S}})\widetilde{\boldsymbol{w}}_t + \tilde{\boldsymbol{S}} \left[(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha})\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}} + (\boldsymbol{\mu}\eta - \boldsymbol{\alpha})\, \tilde{\boldsymbol{\ell}}_{\boldsymbol{t}} + \boldsymbol{\mu} \mathrm{d} \log \bar{z}_t \right] \right\} + \beta \boldsymbol{D} \mathbb{E}_t \tilde{\boldsymbol{v}}_{t+1} \ . \tag{29}$$

E.1.10 Expressing in terms of Uhlig

Substituting Equation 27 into Equation 29 we have,

$$\begin{aligned} \widetilde{\boldsymbol{v}}_t = & \mathbf{1}_{j>0} \cdot \left[\tilde{\boldsymbol{S}}(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha}) - (\boldsymbol{I} - \tilde{\boldsymbol{S}})[\boldsymbol{I} - \boldsymbol{T} - \theta \boldsymbol{M}]^{-1} \theta \boldsymbol{M}(\boldsymbol{I} - \boldsymbol{\mu} - \boldsymbol{\alpha}) \right] \tilde{\boldsymbol{\chi}}_t \\ & + \mathbf{1}_{j>0} \cdot \left[\tilde{\boldsymbol{S}}\, (\boldsymbol{\mu}\eta - \boldsymbol{\alpha}) - (\boldsymbol{I} - \tilde{\boldsymbol{S}})[\boldsymbol{I} - \boldsymbol{T} - \theta \boldsymbol{M}]^{-1} \left[(\boldsymbol{I} - \boldsymbol{T}) + \theta \boldsymbol{M}\, (\boldsymbol{\mu}\eta - \boldsymbol{\alpha}) \right] \right] \tilde{\boldsymbol{\ell}}_t \\ & + \mathbf{1}_{j>0} \cdot \left[\tilde{\boldsymbol{S}} - (\boldsymbol{I} - \tilde{\boldsymbol{S}})[\boldsymbol{I} - \boldsymbol{T} - \theta \boldsymbol{M}]^{-1} \theta \boldsymbol{M} \right] \boldsymbol{\mu} \mathrm{d} \log \bar{\boldsymbol{z}}_t \end{aligned}$$

$$+\beta \boldsymbol{D}\mathbb{E}_t\widetilde{\boldsymbol{v}}_{t+1} \ ,$$

which can be rewritten more compactly as

$$\widetilde{\boldsymbol{v}}_t = \boldsymbol{A}\tilde{\boldsymbol{\ell}}_t + \boldsymbol{B}\tilde{\boldsymbol{\chi}}_t + \boldsymbol{C}\mathrm{d}\log\bar{\boldsymbol{z}}_t + \beta\boldsymbol{D}\mathbb{E}_t\widetilde{\boldsymbol{v}}_{t+1} \ ,$$

where

$$\boldsymbol{A} \equiv \mathbf{1}_{j>0}\cdot\left\{\tilde{\boldsymbol{S}}\left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)-(\boldsymbol{I}-\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\left[(\boldsymbol{I}-\boldsymbol{T})+\theta\boldsymbol{M}\left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\right]\right\} \ .$$
$$\boldsymbol{B} \equiv \mathbf{1}_{j>0}\cdot\left\{\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})-(\boldsymbol{I}-\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\right\} \ .$$
$$\boldsymbol{C} \equiv \mathbf{1}_{j>0}\cdot\left\{\tilde{\boldsymbol{S}}-(\boldsymbol{I}-\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}\right\}\boldsymbol{\mu} \ .$$

Iterating this equation forward in time, we have:

$$\widetilde{\boldsymbol{v}}_t = \mathbb{E}_t\sum_{s=0}^{\infty}(\beta\boldsymbol{D})^s\left(\boldsymbol{A}\tilde{\boldsymbol{\ell}}_{t+s}+\boldsymbol{B}\tilde{\boldsymbol{\chi}}_{t+s}+\boldsymbol{C}\mathrm{d}\log\bar{\boldsymbol{z}}_{t+s}\right) \ .$$

Substituting this into Equation 28, we have

$$\tilde{\boldsymbol{\ell}}_{t+1}-\boldsymbol{E}\tilde{\boldsymbol{\ell}}_t = \frac{\beta}{\rho}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})\mathbb{E}_t\sum_{s=0}^{\infty}(\beta\boldsymbol{D})^s\left(\boldsymbol{A}\tilde{\boldsymbol{\ell}}_{t+s+1}+\boldsymbol{B}\tilde{\boldsymbol{\chi}}_{t+s+1}+\boldsymbol{C}\mathrm{d}\log\bar{\boldsymbol{z}}_{t+s+1}\right) \ .$$

Likewise, the capital law of motion can be rewritten (for $j>0$):

$$\begin{aligned}
\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+1}}+\tilde{\boldsymbol{\ell}}_{t+1} =& \left[\boldsymbol{I}+\left(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta})\right)\left[\Xi\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})-\boldsymbol{\Omega}\right]\right]\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}}\\
&+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})\tilde{\boldsymbol{w}}_t\\
&+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\Xi\tilde{\boldsymbol{S}}\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t\\
&+\left[I+\Xi\left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\left(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta})\right)\tilde{\boldsymbol{S}}\right]\tilde{\boldsymbol{\ell}}_t\\
&-(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\boldsymbol{\Omega}\ \mathrm{d}\log\boldsymbol{\tau}_t^K\\
=&[\boldsymbol{I}+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta})\cdot\\
&\left[\Xi\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})-\boldsymbol{\Omega}-(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\right]\Big]\tilde{\boldsymbol{\chi}}_{\boldsymbol{t}}\\
&+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\left[\boldsymbol{\Xi}\tilde{\boldsymbol{S}}+(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}\right]\boldsymbol{\mu}\mathrm{d}\log\bar{\boldsymbol{z}}_t\\
&+[\boldsymbol{I}+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta})\cdot\\
&\left\{\Xi\left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\tilde{\boldsymbol{S}}-(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\left[(\boldsymbol{I}-\boldsymbol{T})+\theta\boldsymbol{M}\left(\boldsymbol{\mu}\eta-\boldsymbol{\alpha}\right)\right]\right\}\Big]\tilde{\boldsymbol{\ell}}_t\\
&-(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\boldsymbol{\Omega}\mathrm{d}\log\boldsymbol{\tau}_t^K \ ,
\end{aligned}$$

or, equivalently:

$$\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+1}}+\tilde{\boldsymbol{\ell}}_{t+1} = \boldsymbol{J}\tilde{\boldsymbol{\chi}}_t+\boldsymbol{F}\tilde{\boldsymbol{\ell}}_t+\boldsymbol{G}\mathrm{d}\log\bar{\boldsymbol{z}}_t+\boldsymbol{H}\mathrm{d}\log\boldsymbol{\tau}_t^K \ ,$$

where

$$\boldsymbol{J} \equiv \boldsymbol{I}+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\left[\Xi\tilde{\boldsymbol{S}}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})-\boldsymbol{\Omega}-(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}(\boldsymbol{I}-\boldsymbol{\mu}-\boldsymbol{\alpha})\right]$$

$$\boldsymbol{F} \equiv \boldsymbol{I}+(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta})\cdot$$

$$\left\{(\boldsymbol{\mu}\eta-\boldsymbol{\alpha})\,\Xi\tilde{\boldsymbol{S}}-(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\left[(\boldsymbol{I}-\boldsymbol{T})+\theta\boldsymbol{M}\,(\boldsymbol{\mu}\eta-\boldsymbol{\alpha})\right]\right\}$$

$$\boldsymbol{G} \equiv (\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\left[\Xi\tilde{\boldsymbol{S}}+(\boldsymbol{\Omega}-\Xi\tilde{\boldsymbol{S}})[\boldsymbol{I}-\boldsymbol{T}-\theta\boldsymbol{M}]^{-1}\theta\boldsymbol{M}\right]\boldsymbol{\mu}$$

$$\boldsymbol{H} \equiv -(\boldsymbol{I}-\beta(\boldsymbol{I}-\boldsymbol{\delta}))\boldsymbol{\Omega}\ .$$

Analogously,

$$\beta\boldsymbol{D}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}(\tilde{\boldsymbol{\ell}}_{t+2}-\boldsymbol{E}\tilde{\boldsymbol{\ell}}_{t+1})=\beta\boldsymbol{D}\frac{\beta}{\rho}\mathbb{E}_{t+2}\sum_{s=0}^{\infty}(\beta\boldsymbol{D})^{s}\left(\boldsymbol{A}\tilde{\boldsymbol{\ell}}_{t+s+2}+\boldsymbol{B}\tilde{\boldsymbol{\chi}}_{t+s+2}+\boldsymbol{C}\mathrm{d}\log\bar{\boldsymbol{z}}_{t+s+2}\right)\ .$$

Subtracting from the first difference and re-arranging we have

$$\begin{aligned}\beta\boldsymbol{D}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}\tilde{\boldsymbol{\ell}}_{\boldsymbol{t+2}}=&\left[\beta\boldsymbol{D}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}\boldsymbol{E}+(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}-\frac{\beta}{\rho}\boldsymbol{A}\right]\tilde{\ell}_{t+1}\\&-(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}\boldsymbol{E}\tilde{\ell}_{\boldsymbol{t}}-\frac{\beta}{\rho}\boldsymbol{B}\widetilde{\chi}_{t+1}-\frac{\beta}{\rho}\boldsymbol{C}\mathrm{d}\log\bar{\boldsymbol{z}}_{t+1}\ .\end{aligned}$$

Repeating the equation with the capital law of motion, we have

$$\beta(\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+2}}+\tilde{\boldsymbol{\ell}}_{t+2})=\beta(\boldsymbol{J}\tilde{\boldsymbol{\chi}}_{t+1}+\boldsymbol{F}\tilde{\boldsymbol{\ell}}_{t+1}+\boldsymbol{G}\mathrm{d}\log\bar{\boldsymbol{z}}_{t}+\boldsymbol{H}\mathrm{d}\log\boldsymbol{\tau}_{t}^{K})\ .$$

Then subtracting from the first difference and re-arranging we have,

$$\begin{aligned}\beta(\tilde{\boldsymbol{\chi}}_{\boldsymbol{t+2}}+\tilde{\boldsymbol{\ell}}_{t+2})=&\,(\boldsymbol{I}+\beta\boldsymbol{J})\,\tilde{\boldsymbol{\chi}}_{t+1}+(\boldsymbol{I}+\beta\boldsymbol{F})\,\tilde{\boldsymbol{\ell}}_{t+1}-\boldsymbol{J}\tilde{\boldsymbol{\chi}}_{t}-\boldsymbol{F}\tilde{\boldsymbol{\ell}}_{t}\\&+(\beta-\boldsymbol{I})\boldsymbol{G}\mathrm{d}\log\bar{\boldsymbol{z}}_{t}+(\beta-\boldsymbol{I})\boldsymbol{H}\mathrm{d}\log\boldsymbol{\tau}_{t}^{K}\ .\end{aligned}$$

Stacking the two second order difference equations we get:

$$\begin{aligned}\begin{bmatrix}\beta\boldsymbol{D}(I-\boldsymbol{E}\boldsymbol{D})^{-1} & 0\\ \beta\boldsymbol{I} & \beta\boldsymbol{I}\end{bmatrix}\begin{bmatrix}\tilde{\boldsymbol{\ell}}_{t+2}\\ \tilde{\boldsymbol{\chi}}_{t+2}\end{bmatrix}=&\begin{bmatrix}\Upsilon_{11} & \Upsilon_{12}\\ \Upsilon_{21} & \Upsilon_{22}\end{bmatrix}\begin{bmatrix}\tilde{\boldsymbol{\ell}}_{t+1}\\ \tilde{\boldsymbol{\chi}}_{t+1}\end{bmatrix}+\begin{bmatrix}\Theta_{11} & 0\\ \Theta_{21} & \Theta_{22}\end{bmatrix}\begin{bmatrix}\tilde{\boldsymbol{\ell}}_{t}\\ \tilde{\boldsymbol{\chi}}_{t}\end{bmatrix}\\&+\begin{bmatrix}\Pi_{11} & 0\\ \Pi_{21} & \Pi_{22}\end{bmatrix}\begin{bmatrix}\mathrm{d}\log\bar{\boldsymbol{z}}_{t}\\ \mathrm{d}\log\boldsymbol{\tau}_{t}^{K}\end{bmatrix},\end{aligned}$$

where

$$\Upsilon_{11}\equiv\left[\beta\boldsymbol{D}(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}\boldsymbol{E}+(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}-\frac{\beta}{\rho}\boldsymbol{A}\right]$$

$$\Upsilon_{12}\equiv-\frac{\beta}{\rho}\boldsymbol{B}$$

$$\Upsilon_{21}\equiv\boldsymbol{I}+\beta\boldsymbol{F}$$

$$\Upsilon_{22}\equiv\boldsymbol{I}+\beta\boldsymbol{J}$$

$$\Theta_{11}\equiv-(\boldsymbol{I}-\boldsymbol{E}\boldsymbol{D})^{-1}\boldsymbol{E}$$

$$\Theta_{21} \equiv -\boldsymbol{F}$$
$$\Theta_{22} \equiv -\boldsymbol{J}$$
$$\Pi_{11} \equiv -\frac{\beta}{\rho}\boldsymbol{C}$$
$$\Pi_{21} \equiv (\beta - 1)\boldsymbol{G}$$
$$\Pi_{22} \equiv (\beta - 1)\boldsymbol{H} \ .$$

We apply Uhlig's toolbox to compute the impact and transition matrix.

E.2 Calibration

Calibration of the model requires information on labor flows across industries and subsidy regions, trade flows across regions for each industry, value added in each industry-region pair, employment in each industry-region pair, and productivity and capital wedge changes that are directly due to the subsidy program.

Our economy has six regions and 45 industries.[45] We set a time period to refer to an individual year.

We have discussed our calibration of the productivity and capital wedge shocks in the body of the paper. Beyond these moments, we require parameters governing (i) consumers' preferences, (ii) production function cost shares, (iii) trade and migration flows in the baseline economy, (iv) heterogeneity in individual households' preferences, (v) trade elasticities, (vi) the extent to which capital investors earn income from subsidy regions other than where they reside, (vii) the strength of agglomeration economies, and (viii) the regions in which investors' income are

[45] The 45 industries in our analysis include: Crops (NACE A01); Forestry (NACE A02); Fishing (NACE A03); Mining (NACE B); Food, Drinks (NACE C10-C12); Clothing (NACE C13-C15); Wood (NACE C16); Paper (NACE C17); Printing (NACE C18); Petroleum (NACE C19); Chemicals (NACE C20); Plastics (NACE C22); Non-metallic Minerals (NACE C23); Basic Metals (NACE C24); Fabricated Metals (NACE C25); Computers (NACE C26); Electrical Equipment (NACE C27); Misc. Machinery (NACE C28); Motor Vehicles (NACE C29); Other Transportation (NACE C30); Furniture (NACE C31-C32); Electricity (NACE D35); Water Supply (NACE E36); Waste Management (NACE E37-E39); Construction (NACE F); Motor Vehicle Wholesale/Retail (NACE G45); Other Wholesale (NACE G46); Other Retail (NACE G47); Pipeline Transport (NACE H49); Water Transport (NACE H50); Air Transport (NACE H51); Warehousing (NACE H52); Accommodation, Food Service (NACE I); Telecommunications (NACE J61); Information Service (NACE J62, J63); Finance (NACE K64); Insurance (NACE K65); Other Finance, Insurance (NACE K66); Real Estate (NACE L68); Professional (NACE M74-M75); Administrative Support (NACE N); Public Admin. (NACE O84); Education (NACE P85); Health (NACE Q); and Arts, Entertainment (NACE R-S).

The Turkish National Input-Output Tables, as collected by the World Input-Output Database, applies an industry classification scheme with 56 industries. The input-output table includes 11 industries with 0 values in all of the data entries. We drop these 11 industries from our analysis. They are Pharmaceutical Manufacturing (NACE C21); Repair and installation of machinery and equipment (NACE C33); Postal and courier activities (NACE H53); Publishing activities (NACE J58); Motion picture, video, and television program production and planning (NACE J58-J59); Legal, accounting, and management consultancy activities (NACE M69-M70); Architectural and engineering activities (NACE M71); Advertising and market research (NACE M73); Activities of extraterritorial organizations and bodies (NACE T); Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (NACE U).

spent.

To calibrate our model, we rely on information from the World Input-Output Database and the Entrepreneur Information System. The former is informative about aggregate moments, while the latter pins down flows of commodities across regions and the flows of workers across industry-region pairs. For the few moments for which neither of these databases is informative, we draw on estimates from the literature.

The parameters ψ^j characterize the relative importance of each industry commodity j in consumers' preferences. From the 2016 vintage of the World Input-Output Database, for each industry we compute the sum of the value private household consumption expenditures, consumption expenditures by non-profit organizations serving households, governmental consumption expenditures, and exports. We take data from 2011. We then compute the share of industry k among these total expenditures.

The parameters μ^j, α^j, and $1-\alpha^j-\mu^j$characterize the relative importance of labor, capital, and land in value added for intermediate goods producers in industry j. For the country as a whole, we compute μ^j as the cost share of labor relative to value added in industry j. The World Input-Output Database unfortunately does not measure the cost share of land within value added. Consistent with the estimates from Fernald (2015), we assume that the land share of capital is 0.10. While, in principle, these parameters are allowed to vary by subsidy region, the World Input-Output Database does not capture this geographic variation. As a result, we set μ^j and α^j to be identical across all regions. The parameters γ^{jk} characterize the importance of commodity j in the production of intermediate good k when producing in region n. We set γ^{jk} as industry k's share of material input expenditures (from 2011) within the production of commodity j, using the 2016 vintage of the World Input-Output Database.

We use the Entrepreneur Information System dataset to compute $\mathbf{D}$ and $\mathbf{E}$. These matrices measure the flows of people and goods across regions and industries in the baseline economy. We describe our measurement of these flows — accounting for the fact that the EIS sample frame omits informal firms, and most firms in the Agricultural, F.I.R.E., and Public Administration sectors.

We take parameters — θ and ρ — respectively characterizing the heterogeneity in productivity and individuals' idiosyncratic utility from working in a given industry-region pair from Kleinman et al. (2023). We set $\theta = 5$ and $\nu = 2.85$. We set the annual discount factor, β, to be 0.95, and the capital depreciation rate, δ, to be 0.05 again following Kleinman et al. (2023).

In their review of agglomeration economies Combes and Gobillon (2015) write that the elasticity of local productivity to employment or population density are typically found to be between 0.04 and 0.07. On this basis, we set $\eta = 0.05$.

For home bias of capital investment, we set $\lambda = 0.5$. Finally, we set ς^n — the share of landlord profits accruing to each region — to be proportional to that region's gross output in 2011: $\varsigma = [0.616, 0.127, 0.109, 0.073, 0.036, 0.039]$. This approach differs from that in Caliendo et al. (2019), who use observed trade imbalances to identify ς^n.

Additional References

Eurostat (2021a): "Employment by Sex, Age, Full-time/Part-time, Professional Status and NUTS 2 Regions," https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFE2EFTPT/default/table?lang=en.

——— (2021b): "Population on 1 January by Age, Sex and NUTS 2 Region," https://ec.europa.eu/eurostat/databrowser/view/DEMO_R_D2JAN/default/table?lang=en.

Kaplan, G. and G. L. Violante (2014): "A Model of the Consumption Response to Fiscal Stimulus Payments," *Econometrica*, 82, 1199–1239.

Moll, B. (2014): "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?," *American Economic Review*, 104, 3186–3221.

Turkish Statistical Institute (2022c): "Gross Domestic Product per Capita by Provinces," https://data.tuik.gov.tr/Bulten/Index?p=37188&dil=2.