Cross-Sectional Labor Dynamics After Foreign Shocks*

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Abstract

We estimate the cross-sectional effects of foreign shocks on labor market outcomes for a small open economy (SOE). We identify two sources of foreign shocks for the case of Chile: a corporate spread shock, and a shock to the price of copper. Based on a SOE assumption, we propose instruments to estimate the effect of changes in corporate spreads and the price of copper. Using confidential microdata, we unveil substantial heterogeneity in responses to contractionary foreign shocks. Employment decreases the most for low-income earners, and the effect monotonically disappears as income increases, being muted for top-income earners. About 2/3 of this cross-sectional variation in employment responses is due to heterogeneity in responses of separation rates, and the remaining 1/3 is due to heterogeneity in job-finding rates. The effect of labor income is shaped as an "inverse-U", with no effect for low- and top-income earners, but significant declines for middle-income earners. We develop a directed search model with three key assumptions: on-the-job search, downward wage rigidity, and minimum wages. We are argue that these features are crucial in accounting for the estimated heterogeneity in responses.

JEL: F31, F41, F44

Keywords: labor markets, heterogeneity, empirical methods, directed search.

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1 Introduction

A rich literature measures the cyclicality of labor market outcomes depending on workers demographic groups–such as age, race, and education.[1] More recently, the availability of administrative data enabled to study the labor income cyclicality across the income-distribution on workers (Guvenen, Ozkan and Song, 2014). However, there is still limited work analyzing how recessions affect labor flows–such as job separation and finding rates–across the income-distribution on workers. The main limitation has typically been the annual frequency of administrative data, which prevents estimating the high frequency cross-sectional responses of labor flows during recessions. This naturally limits the fast growing literature modeling rich heterogeneity in labor markets.[2] In this paper, we aim to bridge the gap.

This article has two contributions. First, we estimate the effect that recessions induced by foreign shocks have on labor market outcomes across the income-distribution of workers, using a monthly panel of individual labor market outcomes. We find substantial heterogeneity in responses of employment, job finding rates, and separation rates, with low-income workers being exposed the most. As a second contribution, we develop a directed-search model of the labor market that accounts for the estimated heterogeneity. We argue that on-the-job search, downward wage rigidity, and minimum wages are key elements to explain the estimated heterogeneity.

We perform our analysis for Chile, which provides two main advantages: a clean identification of macroeconomic shocks, and the availability of a high quality panel data on monthly individual labor market outcomes. Since Chile is a small open economy, we can identify foreign shocks that are independent of conditions in Chile but likely to affect its economy. We argue that these foreign shocks can be used as instruments to tease out the effect of variables that are, to some extent, driven by international factors. In particular, we estimate the effect of changes in spreads for Chilean corporations and in the price of copper, two variables typicality seen as important for Chile, and both at least partially driven by international factors.[3] As instrument for corporate spread, we use innovations to the *excess bond premia* (EBP) measure as proposed in Gilchrist and Zakrajšek (2012). Analogously, as an instrument for the price of copper, we estimate a shock to the global demand of copper following the methodology in Kilian (2009). We show that these foreign shocks are highly correlated with the corporate spread and copper price and, by construction, likely orthogonal to other variables that may affect economic conditions in Chile (such as GDP in foreign

[1]See Freeman, Gordon, Bell and Hall (1973), Clark and Summers (1980), and Bergman, Matsa and Weber (2020) more recently.

[2]See Bilal, Engbom, Mongey and Violante (2019) for a recent discussion on developments in labor market models.

[3]For studies arguing that global financial shocks affects small open economies, see Neumeyer and Perri (2005), Garcia-Cicco, Pancrazi and Uribe (2010), Caballero, Fernández and Park (2019), and citations therein. For studying analyzing the effect of commodity prices, see Mendoza (1995), Schmitt-Grohé and Uribe (2018),Fernández, González and Rodriguez (2018), and citations therein.

economies). This deems the foreign shocks we propose as valid instruments.

The second motive for focusing in Chile is the availability of an employer-employee matched databases that covers the universe of formal employment in Chile. The data is derived from employers' tax forms and compiled by the Chilean tax agency (*Servicio de Impuestos Internos*). Importantly, the database has a monthly frequency, which allows us to estimate the high frequency response of labor market outcomes to foreign shocks. This high-frequency high-quality panel, combined with a clean identification of macroeconomic shocks, provides an ideal design to estimate the cross-section of labor outcome responses after macroeconomic shocks.

We find that foreign shocks have a large effect on macroeconomic variables, and the effects are very unevenly distributed across workers. A 1 pp increase in corporate spreads leads to a 5% decline in GDP after a year, and almost a 2 pp increase unemployment during the same time. This increase in unemployment unequally distributed: employment declines about 7% for the bottom income-quintile of workers, but less than 1% for top income-quintile of workers. About 2/3 of this cross-sectional variation in employment responses is due to heterogeneity in responses of separation rates, and the remaining 1/3 is due heterogeneity in job finding rates. The effects of a decline in the price of copper are similar. Thus, foreign shock have large and unequal consequences on the cross-section of workers.

Motivated by the evidence, we develop a frictional model of the labor market where differences in workers' (permanent) productivity induce a differential exposure to business cycle fluctuations. In particular, we build on a directed-search model with wage posting (Menzio and Shi, 2010) with three key features: minimum wage, downward wage rigidity, and on-the-job search. We also include foreign shocks as a source of business fluctuations.

The model's key mechanism relies on wage frictions that are homogeneous across workers but, depending on workers' productivity, have heterogeneous effects on labor market flows. Because of minimum wages and wage rigidity, firms make lower profits when matched with low-productivity workers. As workers' productivity increases, so do the firms' profits. In turn, market competition (free entry) makes job finding rates higher for more productive workers, and search frictions lessen as workers' productivity increases. As a result, high productivity workers more frequently find "good matches". This is, where the wage is not so high that the firms want to terminate the match, neither so low as the worker wants to quit. On the contrary, low-productivity workers are often in "bad matches", where wages are either too high or too low for their productivity. In turn, business cycle shocks induce large separations for low-productivity matches but have a smaller impact on high-productivity matches. The model generates non-homothetic labor risk profiles, precisely as we estimate in the data.

2 Related Literature

We contribute to the literature by characterizing, both theoretical and empirically, the heterogeneous response of labor income and labor flows across workers' permanent monthly earnings. On the empirical side, several papers study employment dynamics conditional to demographic group (See Freeman, Gordon, Bell and Hall, 1973, Clark and Summers, 1980, Bergman, Matsa and Weber, 2020). They show a larger cyclical variation of employment for less-educated workers and younger workers. Since permanent monthly earnings strongly correlate with demographic characteristics, we complement these papers by focusing on the monthly earnings. Guvenen *et al.* (2014) measures business cycle properties of yearly income growth conditional on yearly permanent income (see also GID). This paper finds that the skewness of the income growth is more cyclical on the permanent income tails (i.e., low and high permanent incomes). We extend this literature by focusing on yearly labor income components, i.e., monthly income and employment statures. Blanco, Drenik and Zaratiegui (2020) studies monthly earnings and employment outcomes during larges devaluations finding faster real earning recoveries for low-income workers. We also find significant monthly real earnings heterogeneity, but to exogenous fluctuations in sovereign spreads and terms of trade.

Motivated by the empirical evidence, on the theory side, we extend a standard directed search model with wage posting (See Menzio and Shi, 2010) to generate heterogeneous cyclical labor market outcomes across permanent incomes. Our contribution is to add permanent workers' productivity shocks in a non-homothetic environment due to minimum cost, and non-re-scaling unemployment benefits and cost of posting vacancies. The model's objective is to endogenize heterogeneous business cycle labor market outcomes to exogenous changes in productivity and interest rates.

3 Evidence

In this section we estimate the effects of foreign shocks on a small open economy (SOE), for the case of Chile. We start describing our empirical method, including the instruments we propose. As we discuss, focusing on a SOE allows to cleanly identify foreign shocks that we can use as instruments. We then estimate the effect of changes in spreads for Chilean corporations and in the price of copper, using the identified foreign shocks as instruments. First we report aggregate effects on Chile's GDP and unemployment, and then estimate the cross-sectional effects on labor market outcomes.

We find that foreign shocks have a large effect on aggregate variables for Chile, which effects are very unevenly distributed. A contractionary foreign shock leads to higher unemployment, but the effect is largely concentrated on bottom-income workers.[something about finding and separation rates] Interestingly, labor income also declines, but the effect is concentrated in middle-income workers. These finding motivate the model in Section 4.

3.1 Local Projections for a Small Open Economy

We estimate the dynamic effects of corporate spreads and price of copper using a local projection method as in Jorda (2005), with an instrumental variable procedure as in Ramey and Zubairy (2018). In particular, we estimate the following

$$Y_{t+h} - Y_{t-1} = c_h + \beta_h S_t + \theta_h X_t + \phi \text{trend}_t + \epsilon_{t+h} \qquad \forall h = 0, 1, \ldots, H \tag{1}$$

where Y_t is the outcome variable of interest (such as unemployment), and S_t is either corporate spreads or price of copper. We include controls X_t, and a time trend. The coefficient β_h captures the h-periods ahead effect of a change of S_t on Y_t. To avoid endogeneity concerns, we estimate equation (1) with a two-stage least square procedure, where we instrument S_t by a foreign shock S_t^*, as we describe below.

We use variations of equation (1) to estimate the aggregate and the cross-sectional effects of changes in corporate spreads and the price of copper. We starts by describing the instruments S_t^* that we use, then move to aggregate estimates, and finally present the cross-sectional estimates. For each case, we discuss the variations of equation (1) that we use.

3.2 Foreign shocks S_t^* as instruments

We exploit that Chile is a small open economy in constructing instruments for corporate spreads and the price of copper. Our key assumption is that substantial variation in both, corporate spreads and the price of copper, are due to foreign shocks which are unrelated to domestic conditions of a small open economy like Chile. More precisely, we instrument corporate spreads by a global financial shock and the price of copper by a shock to global demand for copper, as we explain next.

As a global financial shock, we follow Gilchrist and Zakrajšek (2012) in computing innovations to their *excess bond premia* (EBP) measure. Within a structural VAR, the identifying assumption is that shocks to the EBP affect economic activity and inflation only with a lag, while financial variables can react contemporaneously.[4] We use monthly data from 1973m1 to 2016m2 and include six lags. The quarterly average of our identified shock has a high correlation (0.79) with the quarterly measure computed by Gilchrist and Zakrajšek (2012).

We estimate shocks to the global demand of copper following the methodology used in

[4] The VAR is estimated using the following U.S. variables: (i) unemployment rate, (ii) the log-difference of the industrial production index, (iii) the log-difference of the consumer price index, (iv) the excess bond premium, (v) the 10-year treasury constant maturity rate, and (vi) the Effective (nominal) Federal Funds Rate. Identification is determined by the ordering of the variables. See Appendix C for more details.

Kilian (2009) to estimate oil demand shocks. In particular, we estimate a structural VAR including: (i) global copper production, (ii) global manufacturing production, and (iii) the price of copper. We identify a shock to the global demand of copper by assuming that it can affect copper production only with a lag. We use monthly data from 1997m1 to 2020m2 and include 24 lags.[5]

We feel confident that, being a SOE, ongoing economic conditions in Chile do not significantly affect the EBP measure nor world global manufacturing production. Similarly, the foreign shocks we estimate are, by construction, orthogonal to other variables that may affect economic conditions in Chile (such as GDP in foreign economies). Thus, as long as they correlate with S_t, these foreign shocks are proper instruments to estimate the effects of changes in corporate spreads and price of copper. Appendix C contains more details of the foreign shocks construction, including a first stage analysis.

3.3 Aggregate Effects of Foreign Shocks

We estimate the effects of foreign shocks in output[6] and unemployment for Chile.[7] In particular, we estimate equation (1) by using either *log* of GDP or unemployment as outcome variable Y_t. As controls X_t we have 12 lags of the outcome variable, 12 lags of corporate spreads, 12 lags of the price of copper, and monthly dummies. Time trend is quadratic. We use monthly data from 1996m1 to 2020m3.

Foreign shocks have a large effect on domestic output and unemployment, as Figure 1 shows. Panel (a) shows that 1 pp increase in corporate spreads leads to a 5% decline in GDP after a year, and almost a 2 pp increase unemployment during the same time—for reference, the standard deviation of corporate prices is 0.97 pp. The effect of copper prices, as depicted in panel (b), is also substantial. A 1 standard deviation decline in the price of copper leads to a 4% decline in GDP and 1 pp increase in unemployment.

Foreign shocks also account for a large fraction of business cycle fluctuations in domestic variables. Following the methodology in Gorodnichenko and Lee (2020), we compute the fraction of fluctuations on output and unemployment that can be attributed to foreign shocks S_t^*. Table 1 shows the decomposition at different horizons. Foreign shocks account for about one-third of unemployment fluctuations, and more than 50% of GDP fluctuations.

We conclude that foreign shocks have substantial effects on domestic macroeconomic conditions, and they account for a large fraction of business cycle fluctuations. As we show next, foreign shocks also have large distributional consequences.

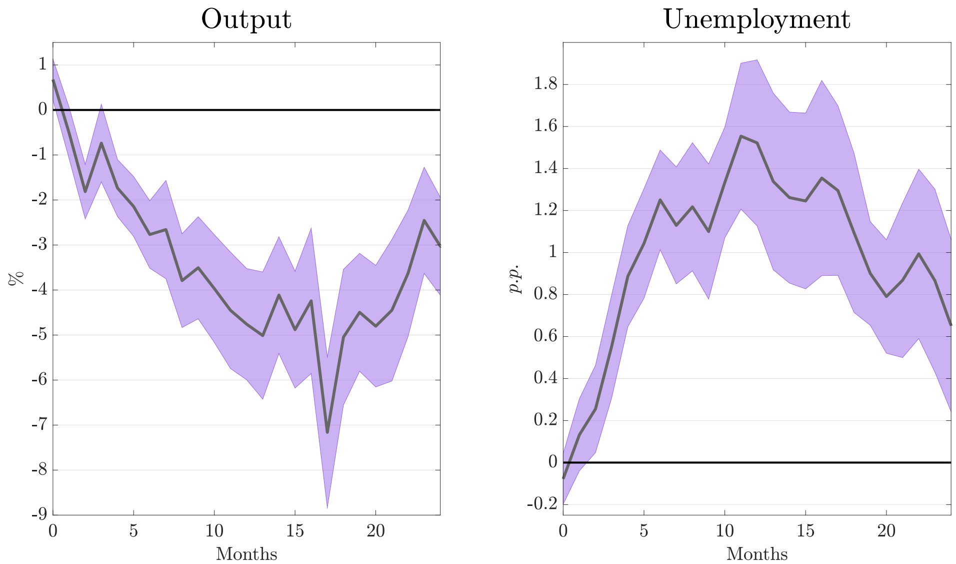
[5]Monthly copper production is obtained from the International Copper Study Group, global manufacturing production is given by the OECD industrial production index, and we use the monthly average of the real copper price in the London Stock Exchange. See Appendix C for more details.

[6]We focus on non-mining GDP, for which we have a monthly series, and is not mechanical affected by changes in the price of copper. See appendix B for more details.

[7]In appendix A, we report results for additional outcome variables: inflation rate, nominal exchange rate, private consumption, and total investment.

Figure 1 – Output and Unemployment Response to Shocks

(a) 1 pp *increase* in corporate spreads



(b) 1 std *decline* in price of copper

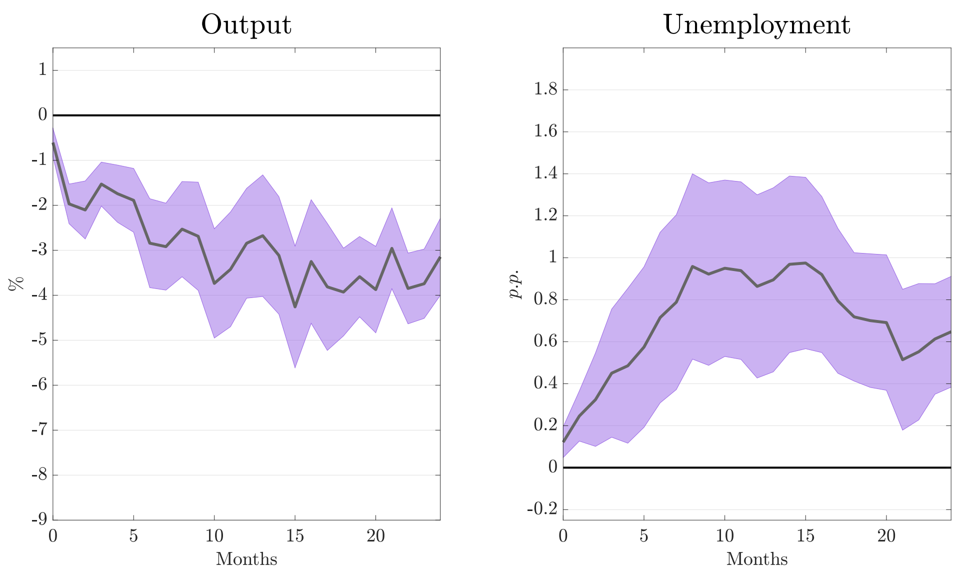


Table 1 – Contribution of Foreign Shocks

	6 months	12 months	24 months
Output	14.1%	32.5%	54.5%
Unemployment	7.9%	15.3%	31.1%

3.4 Cross-Sectional Effects of Foreign Shocks

We use an employer-employee matched database provided by the Chilean tax agency (*Servicio de Impuestos Internos*)[8]. The database covers the universe of formal employment in Chile, which accounts for about 57% of total working individuals.[9] Each month, we can observe if an individual is employed or not. If employed, we observe the firm(s) the individual works at. We also observe the annual income an individual obtained from each of the firms where they worked at. Data is monthly, from 2005m1 to 2018m12. We merge the tax data with the *Servicio de Registro Civil e Identificación*, which provides demographic characteristics for all individuals living in Chile.

Measuring workers' permanent income.—We estimate a worker's permanent income measure from the following regression

$$\ln y_{it} = \alpha_i + \gamma_t + \theta_{\text{age}} + \nu_{it} \tag{2}$$

where y_{it} is the labor of individual i on month t, α_i is a fixed-effect for each individual, γ_t is a time dummy, and θ_{age} is an age-specific dummy.[10] We restrict our sample to males of age between 25 and 55, who are employed for at least seven months in the sample, and who earn at least more than half of the minimum wage. For each worker included, we define the primary job as their highest-paying job in each month. After these cleaning procedures, our sample contains about 339 million of employer-employee observations (about 43% of the initial database). Figure 2 shows the estimated distribution of α_i.

We use the estimate α_i as a measure of the individual's permanent-income. We divide individuals into five groups (quintiles), depending on their permanent-income α_i. For each quintile, we compute their average labor income, and the number of employed workers. Then, we estimate equation (1) for each quintile, using their labor income or employment as outcome variables Y_t. As controls X_t, we use 4 lags of the outcome variable, 4 lags of either the corporate spread or the price of copper, monthly dummies, and a quadratic time trend.

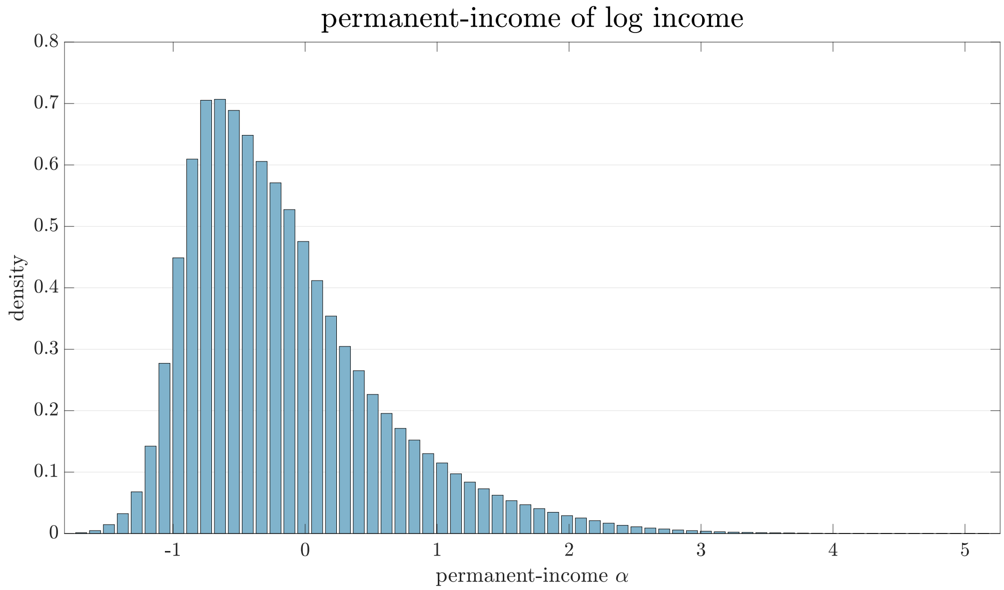
Employment and labor income responses.—We unveil substantial heterogeneity in response to foreign shocks, as Figure 3 shows. Employment decreases for all quintiles, and the effect is substantially larger for the bottom quintiles. A 1pp increase in corporate spreads induces a 7% decline in employment for the bottom quintile, while the effect is a tenth of it for the top quintile. Unlike employment, the response of wages is not monotonic across

[8]The tax agency assigned unnamed identifiers to each firm and worker in the database, to preserve tax secret.

[9]The larger groups absent in the database are: self-employed, business owners, and workers in the informal sector. See Aldunate, Contreras and Tapia (2020) for more details.

[10]We restrain of adding firm fixed-effects in equation (2) for two reasons. First, there are numerous firms in Chile with few workers, which blurs identification of individual fixed-effects, which is ultimately our variable of interest. Second, firm fixed-effects have been estimated to contribute only about 9% of individuals' income cross-sectional variance, while individual fixed-effects explain about 60%. See Aldunate *et al.* (2020).

Figure 2 – A 1 pp *increase* in corporate spreads



quintiles. While middle quintile experience a larger decline in wages, the effect is smaller for top and income quintiles. Nevertheless, heterogeneity in employment is more prevalent than in labor income.

Finding and separation rates.—Let f_{qt} be the fraction of quintile-q workers who were unemployed in month $t-1$ and employed in month t. Similarly, let s_{qt} be the fraction of quintile-q workers who were employed in month $t-1$ and unemployed in month t. We refer to f_{qt} and s_{qt} as the quintile q finding and separation rates, respectively. Let N_{qt} be the number of employed workers from quintile q in month t, and note that

$$N_{qt} = (1 + f_{qt} - s_{qt})\, N_{q,t-1} \tag{3}$$

For each quintile, we compute the contribution of the finding probability to employment by fixing the separation rate to its historical mean in equation (3). Similarly, we compute the contribution of the quintile's separation rate on employment by fixing the finding rate. Let N^f_{qt} and N^s_{qt} be the employment implied by the finding probability and the separation rate, respectively. Then

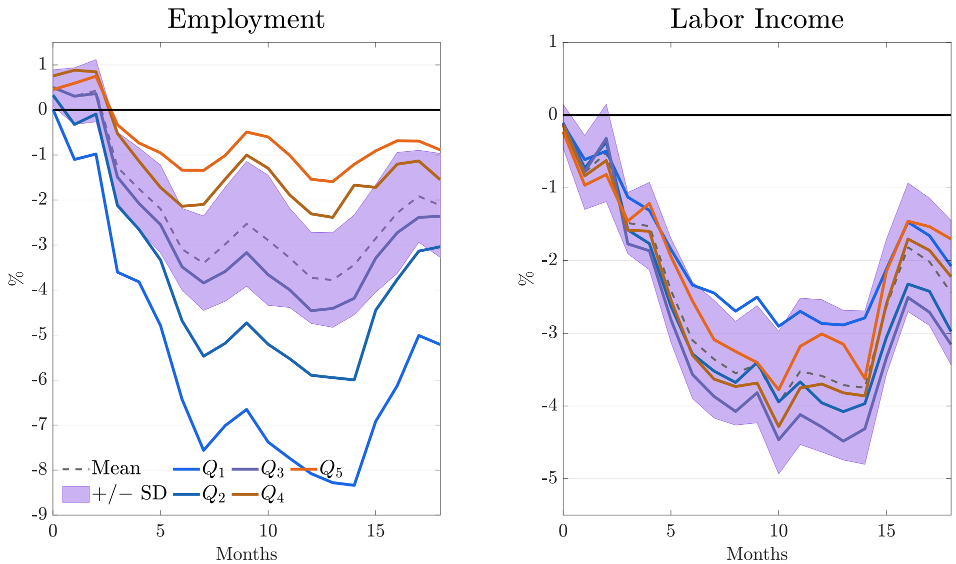
$$N^f_{qt} = \prod_{\tau=1}^{t} (1 + f_{q\tau} - \bar{s}_q) N_{q0} \tag{4}$$

$$N^s_{qt} = \prod_{\tau=1}^{t} (1 + \bar{f}_q - s_{q\tau}) N_{q0} \tag{5}$$

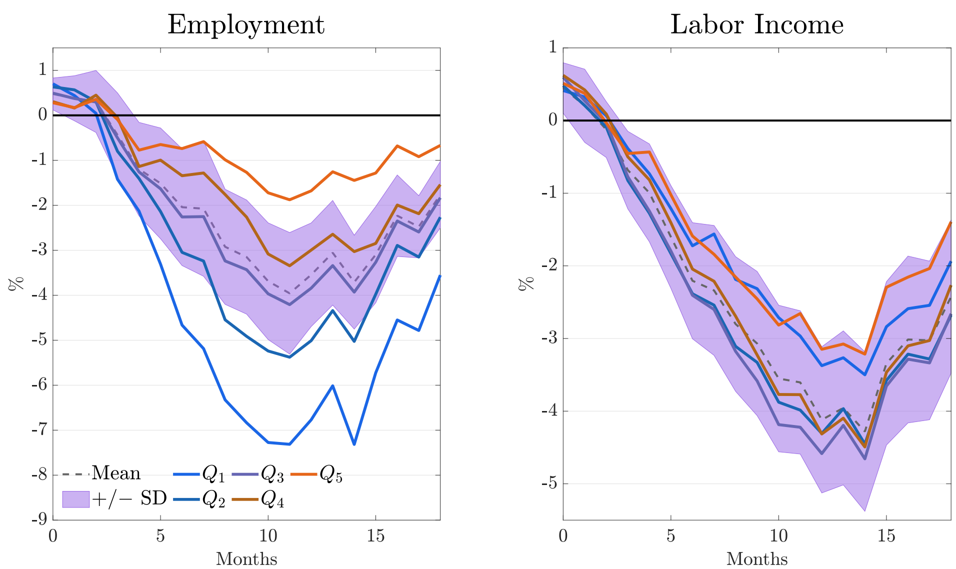
where N_{q0} is the initial employment of the quintile, and $\bar{f}_q$ and $\bar{s}_q$ are the average finding

Figure 3 – Cross-Sectional Responses to Shocks

(a) A 1 pp *increase* in corporate spreads



(b) A 1 std *decline* in price of copper



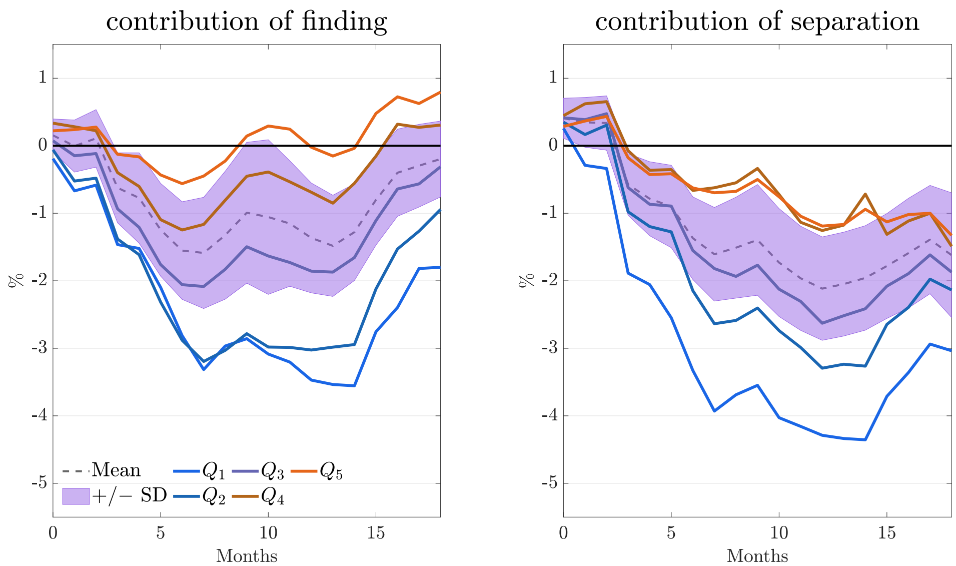
and separation of the quintile.

The response of N_{qt}^{f} and N_{qt}^{s} to foreign shocks is very heterogeneous, as Figure 4 shows. While separation increases for all quintiles, the effect is roughly five times larger for the bottom-income quintiles. Similarly, the finding rate declines for the bottom-quintile, but is roughly muted for top quintiles.

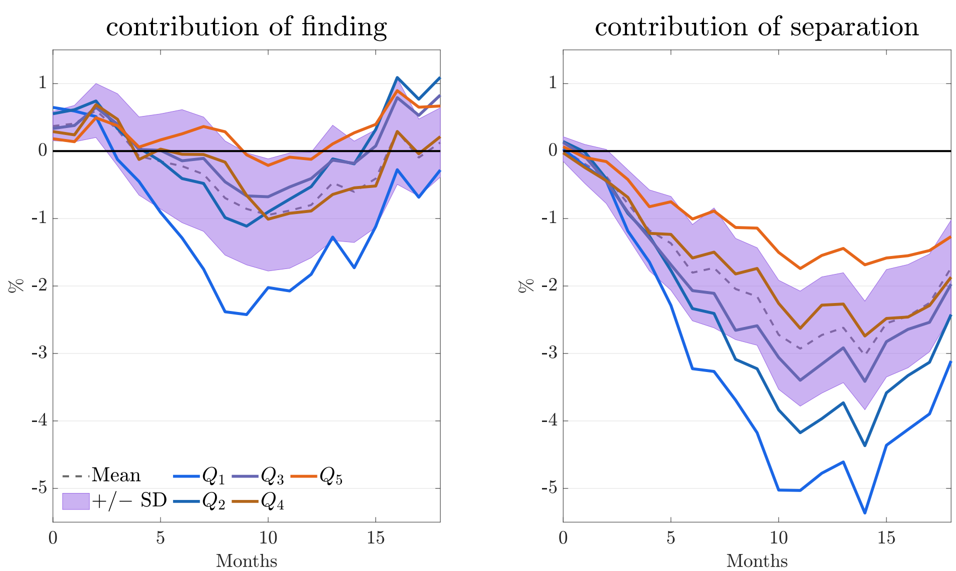
To summarize, foreign shocks lead to a large contraction in employment for bottom income earners, but the effect dissipates as income increases. The heterogeneity in employment is largely due to differences in separation rates, and to a lesser extent to finding probabilities. For labor income, the effect is shaped as an "inverted U": with large contractions for

Figure 4 – Contribution of finding and separation to employment

(a) A 1 pp *increase* in corporate spreads



(b) A 1 std *decline* in price of copper



middle quintiles, but milder effects at the top- and bottom-quintiles.

4 Model

In this section, we develop a model to study heterogeneous business cycle dynamics of labor market outcomes. We build on a directed-search model with wage posting (Menzio and Shi, 2010), with the following features: worker's permanent productivity shocks as a function of employment status, and labor market features such as minimum wage and downard wage rigidity. In line with the empirical section, we add two foreign shocks: interest rate shock and terms-of-trade shock.

4.1 Environment

We assume a small open economy (SOE) populated by a continuum (measure one) of workers and a positive measure of firms. The economy produces a good X which exclusively exports, and consumes a good I which entirely imports. We use the price of imports as the numéraire in the economy, and denote p_t the price of the exported good. Workers are risk-neutral and discount future consumption at rate β. Firms are risk-neutral and discount future flows at rate R_t. There are no financial assets. Thus, workers consume their income every period. We assume that both p_t and R_t follow a Markovian stochastic process and are exogenous to the SOE. Time is discrete, indexed by t, and runs forever.

Workers.—Workers can be either employed (denoted with h) or unemployed (denoted with u). Workers idiosyncratic productivity z evolves stochastically, and the process for z depends on the worker's employment status $e \in \{h, u\}$. While employed, the worker produces z units of the exportable good X and perceives a wage w. Workers may permanently exit the labor market with probability ϕ, in which case they are replaced by an unemployed worker whose initial productivity is $z \sim F_0(z)$.

Labor Market.—Labor markets are indexed by worker's productivity z and the initial wage w. Let $m = (w, z)$ denote each labor market. While unemployed, workers direct their search to a particular wage-market w. Analogously, firms direct their search to a labor market m. The probability a worker finds a job in submarket m is $f(\theta(m)))$, where θ denotes the vacancy-unemployment ratio. There is a per-period cost κ of posting a vacancy with probability of finding a worker $q(\theta(m)) = f(\theta(m))/\theta(m)$. We assume firms operate with one worker only. There is a legal minimum wage $w_{\min}$ below which jobs are not allowed. Employed workers can search on the job with probability λ_e each period.

Firms/Matches.—Wages are downward rigid but can be increased during the duration of the match. In particular, we assume that wages are renegotiated each period with a probability $1 - \lambda^w$. In case of renegotiation, the firm makes a take-it-or-leave-it wage offer that must be larger or equal than the ongoing wage. In case of no agreement, the match is terminated. At any point, a match can be endogenously terminated either by the firm or the worker. Additionally, matches are exogenously separated at rate $\bar{d}$, or terminated with probability ϕ if the worker exits the labor market. There is a per-period fixed operating cost c_o.

Timing.—The timing assumption within the period is the following: (1) the exogenous idiosyncratic productivity z_t and the aggregate shocks (p_t, R_t) are realized, (2) firms make an offer with probability λ^w, (3) finding is realized, (4) endogenous and exogenous separations occur, and (5) wages and unemployment benefits are paid.

4.2 Equilibrium

Let $s = (w, z)$ denote the idiosyncratic state of a match, $S = (p, R)$ be the aggregate state of the economy, and $\mathbb{S} = (s, S)$ and $\mathbb{S}_u = (z, S)$ be the state of a matched and an unemployed worker, respectively. Below we characterize a block-recursive equilibrium, in which firms' and worker's values depend on (s, S) only, and not in the distribution of idiosyncratic states.[11] We define agents recursive problem after the realization of idiosyncratic and aggregate shocks (i.e., between (1) and (2) in the timing assumption above). Let $\tilde{\beta} = \phi\beta$.

Worker's value.— Let $u(\mathbb{S}_u)$ and $h(\mathbb{S})$ be the value of an unemployed and employed worker with state $\mathbb{S}_u$ and $\mathbb{S}$, respectively. The value of an unemployed worker is given by

$$u(\mathbb{S}_u) = \max_{w^u \geq w_{\min}} \left\{(1 - f(\mathbb{S})) \left[b(z) + \tilde{\beta}\mathbb{E}^{uu}_{\mathbb{S}} \left[u(\mathbb{S}'_u)\right]\right] + f(\mathbb{S})[w + \tilde{\beta}\mathbb{E}^{uh}_{\mathbb{S}} \left[h(\mathbb{S}')\right]]\right\}. \tag{6}$$

where we simplified the notation of $f(\theta(\mathbb{S}))$ with $f(\mathbb{S})$. (There is no severance payment for new matches.) The expectations $\mathbb{E}^{UU}_{\mathbb{S}}[\cdot]$ and $\mathbb{E}^{UH}_{\mathbb{S}}[\cdot]$ may differ since the transition probabilities of idiosyncratic productivity is a function of the employment status.

The value of an employed worker is given as

$$\begin{aligned}
h(\mathbb{S}) &= \lambda^w h^*(z, w^f(\mathbb{S}), S) + (1 - \lambda^w)h^*(\mathbb{S}), \qquad (7)\\
h^*(\mathbb{S}) &= \max_{w^h \geq w_{\min}} \left\{(1 - \lambda_e f(z, w^h, S))e(\mathbb{S}) + \lambda_e f(z, w^h, S))e(z, w^h, S)\right\},\\
e(\mathbb{S}) &= d(\mathbb{S}) \left[w + \tilde{\beta}\mathbb{E}^{h}_{\mathbb{S}} \left[h(\mathbb{S}')\right]\right] + (1 - d(\mathbb{S})) \left[b(z) + \tilde{\beta}\mathbb{E}^{hu}_{\mathbb{S}} \left[u(\mathbb{S}'_u)\right]\right].
\end{aligned}$$

where $h^*(\mathbb{S})$ is the value of employment after the potential wage renegotiation, and $e(\mathbb{S})$ is the employment value after the realization of the on-the-job. Finally, $d(\mathbb{S})$ represents the (partially stochastic) separation decision, as we discuss below.

In equation (7), $h^*(\mathbb{S})$ is the employment value function after the possibility to the firm to set up a new wage and $e(\mathbb{S})$ is the employment value after the realization of the finding probability. $d(\mathbb{S})$ represents the stochastic separation decision.

[11] See Menzio and Shi (2010) for a detail discussion of block recursive equilibria.

Firms value.—Let $j(\mathbb{S})$ be the value of a firm with state $\mathbb{S}$. Then

$$j(\mathbb{S}) = \lambda^w \max_{w^f \geq w_{\min}} \left\{ j^*(z, w^f, S) \right\} + (1-\lambda^w) j^*(\mathbb{S}), \tag{8}$$
$$j^*(\mathbb{S}) = (1 - \lambda_e f(z, w^h(\mathbb{S}), S)) d(\mathbb{S}) \left[pz - w - c_0 + \frac{\phi}{R} \mathbb{E}^{hh}_{\mathbb{S}} \left[j(\mathbb{S}') \right] \right].$$

Free entry condition.—The firm's benefit of creating a vacancy in submarket m is the expected profits of hiring a worker times the matching probability, $q(\theta(\mathbb{S}))$. If a submarket m is active–i.e.: if some workers direct their search to market m— the free entry condition is given as

$$\kappa \geq q(\theta(\mathbb{S})) \left[pz - w - c_0 + \frac{\phi}{R} \mathbb{E}^{hh}_{\mathbb{S}} \left[j(\mathbb{S}') \right] \right], \tag{9}$$

and $\theta(\mathbb{S}) \geq 0$, with complementary slackness.

Separation decisions.— The function $d(\mathbb{S})$ is given by

$$d(\mathbb{S}) = \begin{cases} 1 & \text{if } j(\mathbb{S}) \geq 0 \ \text{ and } w + \tilde{\beta} \mathbb{E}^{hh}_{\mathbb{S}} \left[h(\mathbb{S}') \right] \geq b(z) + \tilde{\beta} \mathbb{E}^{hu}_{\mathbb{S}} \left[u(\mathbb{S}') \right] \\ \bar{d} & \text{Otherwise} \end{cases} \tag{10}$$

Equilibrium definition.—A block recursive equilibrium is a set of function

$$\{u(\mathbb{S}), h(\mathbb{S}), j(\mathbb{S}), \theta(\mathbb{S})\}, \tag{11}$$

such that: (i) $u(\mathbb{S})$, $h(\mathbb{S})$, and $j(\mathbb{S})$ satisfy (6), (7), and (8), and (ii) the free entry condition (9) holds in any market with positive vacancies.

4.3 Calibration

This section describes the calibration and the technical modification to the model to simplify its numerical solution.

Calibration.—We parameterize the model as follow. Following Menzio and Shi (2010), we choose the CES contact rate functions

$$f(\theta) = \theta \left(1 + \theta\right)^{-1/\gamma} \quad ; \quad q(\theta) = \left(1 + \theta\right)^{-1/\gamma}. \tag{12}$$

Following Storesletten, Telmer and Yaron (2004), we select log-normal distribution for the productivities distribution at the entering of the labor force, i.e., $F_0(z) \sim \mathbb{LN}(-\frac{\sigma^2_{z0}}{2}, \sigma_{z0})$. We pick a random walk with drift for workers' stochastic productivity, i.e.,

$$\log(z_t) = \mu_{ee} + \log(z_{t-1}) + \sigma \epsilon_t, \ \text{with } \epsilon_t \sim_{i.i.d.} \mathbb{N}(0, \sigma_z), \ e \in \{h, u\}. \tag{13}$$

Finally, we follow Kehoe, Midrigan and Pastorino (2019) and we use for unemployment flow

Table 2 – Calibration

Parameters	Values
Preferences Parameters:	
Discount factor (β)	0.96
Continuation probability (ϕ)	0.97
Labor Market Parameters:	
Matching function parameter (γ)	1.59
On the job search probability (λ_e)	0.50
Wage renegociation probability (λ_w)	0.90
Cost of posting vacancies (κ)	0.80
Constant flow payment unemployment (b_0)	0.20
Linear flow payment unemployment (b_1)	0.75
Exogenous separation probability ($\bar{d}$)	0.01
Minimin wage(w_{min})	0.45
Worker idiosyncratic productivity parameters:	
Percentage conditional growth ($\mu_{hh}, \mu_{hu}, \mu_{uu}$)	(0.15, 0.00, 0.00)
Percentage std. productivity growth (σ_z)	3.20
Percentage std. initial productivity (σ_{z0})	50.00

Notes: The table presents the calibrated parameters in the model.

payoff a linear function $b(z) = b_0 + b_1 z$.

Table 2 describes the calibrated parameter and Table 3 describes the target moments in the data and in the model. A period in the model is a month. Therefore, we choose a discount factor of $\beta = 0.96^{1/12}$ to match an annual discount factor of 0.96 and an exit probability equal to $\phi = (1 - 1/31)^{1/12}$ to match an average working life of 31 years (i.e., from 25 to 55 included years old). We calibrate the matching function parameter γ as in Schaal (2017).

For the labor market parameters, we target labor market flows in the formal sector and its size. Ceteris paribus (b_0, b_1), the employment share in the model is given by the cost of posting vacancies κ. Thus, we select this parameter to match the share of non-formal employment in Chile. The probability of receiving a job offer λ_e and the exogenous separation probability $\bar{d}$ target the job-to-job and the separation transition probabilities. Given the lack of monthly income data in our data, we target the probability of wage increase in Blanco, Diaz de Astarloa, Drenik, Moser and Trupkin (2021) computed during the low inflation period in Argentina (another emerging country). Thus, λ_w is set to math the monthly probability of wage increases. Finally, we choose (b_0, b_1) to match the difference between the informal minus formal (log) income.

For the workers' stochastic process parameter and minimum, we assume μ_{hu}, μ_{uu}, and μ_{hu} equal to zero, and the rest of the parameter are set to match cross-sectional moments and cumulated income risk over the life-cycle. Intuitive, the average income and standard deviation across age profile identify the income growth during employment states (μ_{ee}) and the productivity growth σ_z. Finally, the initial dispersion at the moment of entering the labor market σ_{z0} and the minimum wage is w_{min} target truncated total income dispersion.

Table 3 – Labor market moments: Model-data

Moments	Data	Model
Labor market moments:		
Share formal employment	0.85	0.86
Job-to-job trans. probability	2.54	2.69
Separation trans. probability	4.09	4.29
Wage increase probability	0.05	0.04
Difference non-formal vs. formal sector	-0.62	-0.85
Cross-sectional monthly earning moments:		
Std. income	0.81	0.88
Skewness income	0.87	0.91
5th Percentile-Mininum wage	0.32	0.24
25th Percentile-Mininum wage	0.77	0.76
50th Percentile-Mininum wage	1.26	1.25
75th Percentile-Mininum wage	1.82	1.88
95th Percentile-Mininum wage	2.94	3.18
Monthly earning moments cond. on age:		
(Mean, Std.) 25 years old	(-0.00, 0.50)	(0.00, 0.45)
(Mean, Std.) 35 years old	(49.17, 0.78)	(19.35, 0.57)
(Mean, Std.) 45 years old	(51.13, 0.85)	(38.54, 0.67)
(Mean, Std.) 55 years old	(51.93, 0.87)	(54.81, 0.75)

Notes: The table presents selected moments of the monthly earnings and labor market statsitics in the data and in the model. The first block of rows (i.e., rows 1 to 4) describes labor market flow of the formal chilean sector and total formal employment. The data target for the monthly probability of monthly wage increase is from Blanco *et al.* (2021). The second block of rows (i.e., rows 5 to 11) describes the log monthly earning moments in the cross-section. The last block of rows (i.e., rows 12 to 15) describes the log monthly earning moments for different age groups. We normalize the mean log earning at age 25 to 0.

Technical modifications.—There are two technical challenges for solving the model numerically. First, the value functions of employed workers and firms are discontinuous at the separation wage triggers limiting interpolation methods. For example, take a low wage such that the worker is indifferent between continue the match and finishing the match. Since the worker is indifferent, the maximum between the two options, i.e., the worker's value function, is continuous. Nevertheless, at the low wage separation trigger, the firm strictly prefers to continue the match—i.e., it has a positive value—but this value jumps to zero for any lower value in the wage. Therefore, the firm's value function is discontinuous at the lower wage separation trigger. This property applies to the high wage separation trigger. To overcome this property, we include an i.i.d. small random shock to paid wages.

The second challenge is static strategic interaction between the worker and the firm. From equations (7) and (8), we can see that, given a workers policy, the firm chooses the new wage. Moreover, the worker should consider the firms' new wage when setting its wage policy. We find it challenging to find the fixed point of (6) to (9). For this reason, we set $\lambda_e = 0$ if there is a possibility of a wage offer.

4.4 Non-Homothetic Steady-State Labor Risk Profiles

This section describes the steady-state trade-off and its impact in the policy functions for an unemployed worker, an employed worker, and a firm. The aim is to discuss the steady-state heterogeneity in wages, finding probabilities, and separation probabilities, across different productivity levels z. This is what we refer to as labor risk profiles.

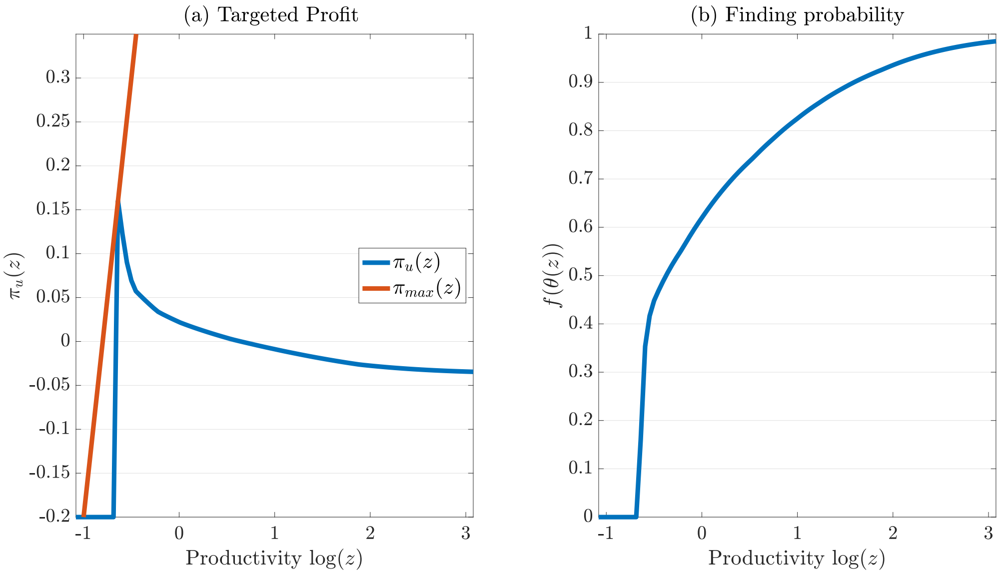
To this regard, it is convenient to redefine the state from (w, z) to $(\pi, \log(z))$, where π is the firm's productivity-to-wage log-ratio: $\pi = \log(z) - \log(w)$. Notice that a firm per-period profit is $\exp^{\pi} z$. Similarly, define $\pi_u(z) = \log(z) - \log(w_u(z))$, $\pi_h(z) = \log(z) - \log(w_h(z))$, and $\pi_f(z) = \log(z) - \log(w_f(z))$, as the targeted productivity-to-wage log-ratios that unemployed workers, employed workers, and firms chose when they can re-set wages. From now on, we refer to $\pi_i(z)$ as the *targeted profit*, for $i = u, h, f$.

Unemployed worker's policy.—The finding probability of an unemployed worker increases with their productivity z and the targeted productivity-to-wage $\pi_u(z)$ declines, as Figure (5) shows. These policies are at the core of the model mechanism–so, it's worth describing it carefully. The cost of posting a vacancy is κ, which is independent of the workers productivity z. When productivity z is very low, there is no wage w above the minimum $w_{\min}$ that generate a positive value to the firm. Thus, the finding probability is zero for low z values. As z increases, the workers wage $w_u(z)$ increase ($\pi_u(z)$ lowers), but not as fast as z itself. Thus, at the *targeted profit*, the firm's profits increase with the workers productivity z. In turn, the free-entry condition in (9) implies a finding probability that increases in z.

Employed worker's policy.—The separation policy follows the rationale of an Ss-type model. As in the Ss model, there is a separation/action if profits π are either to large or to low. Unlike an Ss model, separation in this model is decided by two agents. If the profit π is too low, the firm optimally decides to terminate the match. If the profit π is too high, the worker decides optimally to quick its job. This is what panel (c) in Figure (6) shows.

Importantly, high-z workers more frequently separate and transition to other jobs, as panels (b) and (c) in Figure (6) shows. If the current profits of the match are at the *targeted profit*, there is no incentive to search for another job–finding is zero in panel (b). As the profit π increases, the worker's wage is low relative to their productivity, and thus have an incentive to search for another job. For a high-z finding another job is easier because, as just discussed above, the finding probability increases with workers productivity

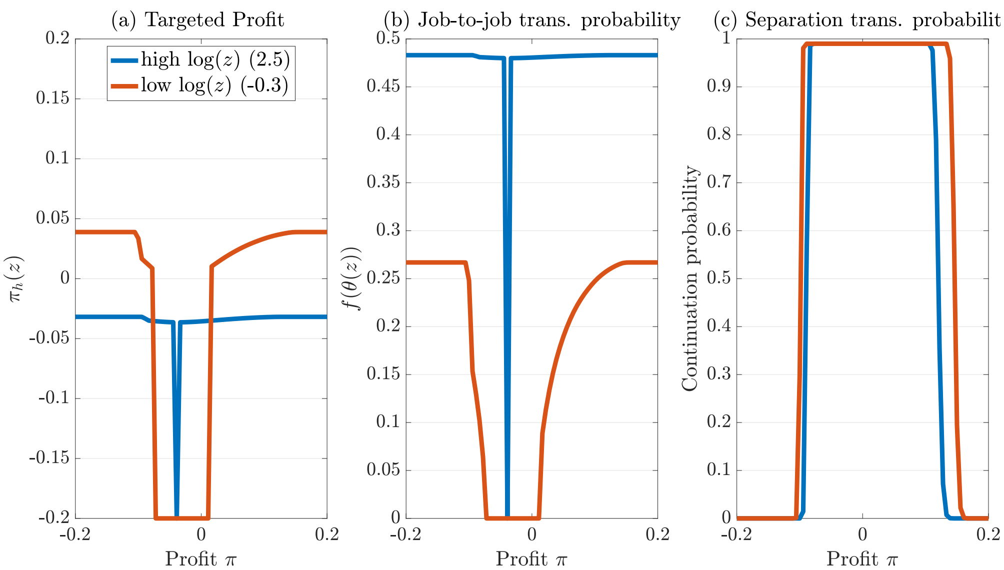
Figure 5 – Unemployment Worker's Policy Function



Notes: Panel a and b describe unemployed workers' policy function. Panel a (resp. b) plots the target profit gap (resp. finding probability) policy for an unemployed worker as a function of current productivity. The blue lines describe the worker's for policy, and the red line describes the minimum wage rigidity constrain in the profit gap dimension.

z. Thus, as soon as current profits are away from the *targeted profit*, high-z worker quickly search for another job. For low-z workers, finding another job opportunity is not as simple, and thus they remain inactive for a larger range of π values.

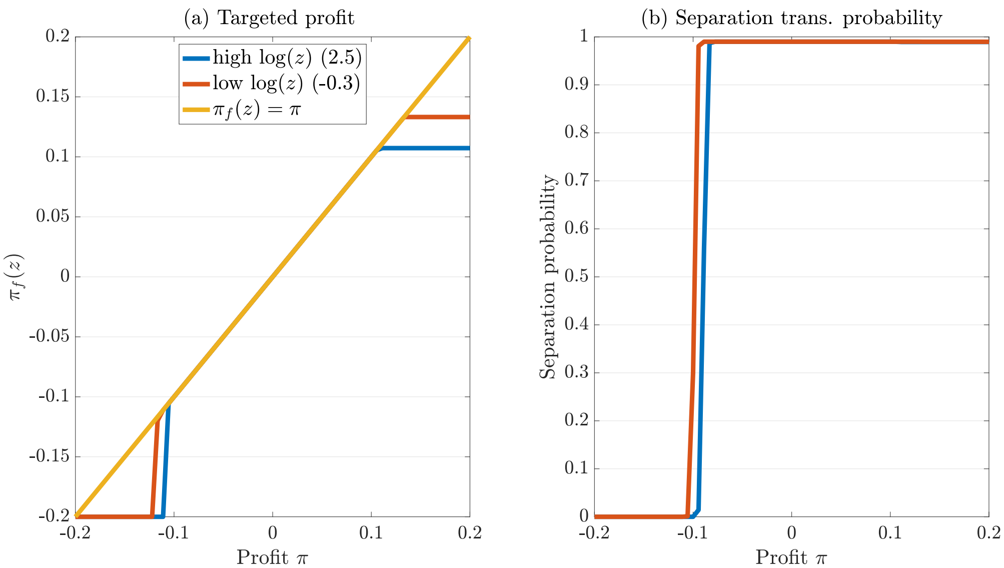
Figure 6 – Employment Worker's Policy Function



Notes: Panel a, b, and c describe employed workers' policy functions. Panel a to c plot (in the following order) the target profit gap, the finding probability, and separation probability for an employed worker as a function of the current productivity gap. The blue lines describe the worker's policy for those with high log productivity (2.5), and the red lines describe the worker's policy for those with low log productivity (-0.3).

Firm's policy.—Figure (7) plots the firm's policy for high and low productivity workers, conditional on having a bargaining opportunity to reset profits π. As with the worker, two mechanisms determine the firm's optimal *targeted profit*—the statics flow profits and the separation probability. Firms with high profit intermediate levels of profits π do not pass an increase in profits to wages. However, when profits are large enough, the firm passes any additional increase in profits to the worker, in order to avoid an endogenous quit.

Figure 7 – Firm's Policy Function



Notes: Panel a and b describe firms' policy function conditional on having access to a commitment technology to change wages. Panel a (resp. b) plots the target profit gap (resp. separation probability) policy for a firm as a function of the current profit gap. The blue lines describe the firm's policy for high productivity workers (2.5 in logs), and the red lines describe the firm's policy for low log productivity (-0.3 in logs). The yellow line plots the downward wage rigidity constrain in the profit gap dimension.

Labor risk profiles.—The positive relation between wages and productivity at the *targeted profit* is the key element in the model. It implies that productive workers generate more profits for firms, and thus can more easily find job opportunities. In turn, they will be more often close to the *targeted profit*, and suffer lower job separation rates in equilibrium. On the contrary, low-z workers do not generate as much profits for the firm, and their matches will be destroyed more frequently. This will make the business cycle more volatile for low-z than for high-z workers, as we find in the empirical part. We show this next.

5 Conclusions

This paper studies labor market outcomes across the income-distribution of workers following foreign shocks. In particular, we study monthly earnings and employment dynamics conditional to corporate spread and price cooper shocks. Employment decreases the most for low-income earners, and the effect monotonically disappears as income increases, while monthly earnings have an “inverse-U”, with no effect for low- and top-income earners, but significant declines for middle-income earners. We develop a directed search model with wage posting, permanent stochastic workers’ productivities, and homogenous frictions in wage setting. In the model, worker are heterogenous in the cost of posting vacancies and unemployment income relative to their productivities, which makes them heterogeneous in their separation and finding probabilities. We are argue that these features are crucial in accounting for the estimated heterogeneity in responses.

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A Additional Figures

Figure A.1 – Response to 1 pp *increase* in corporate spreads

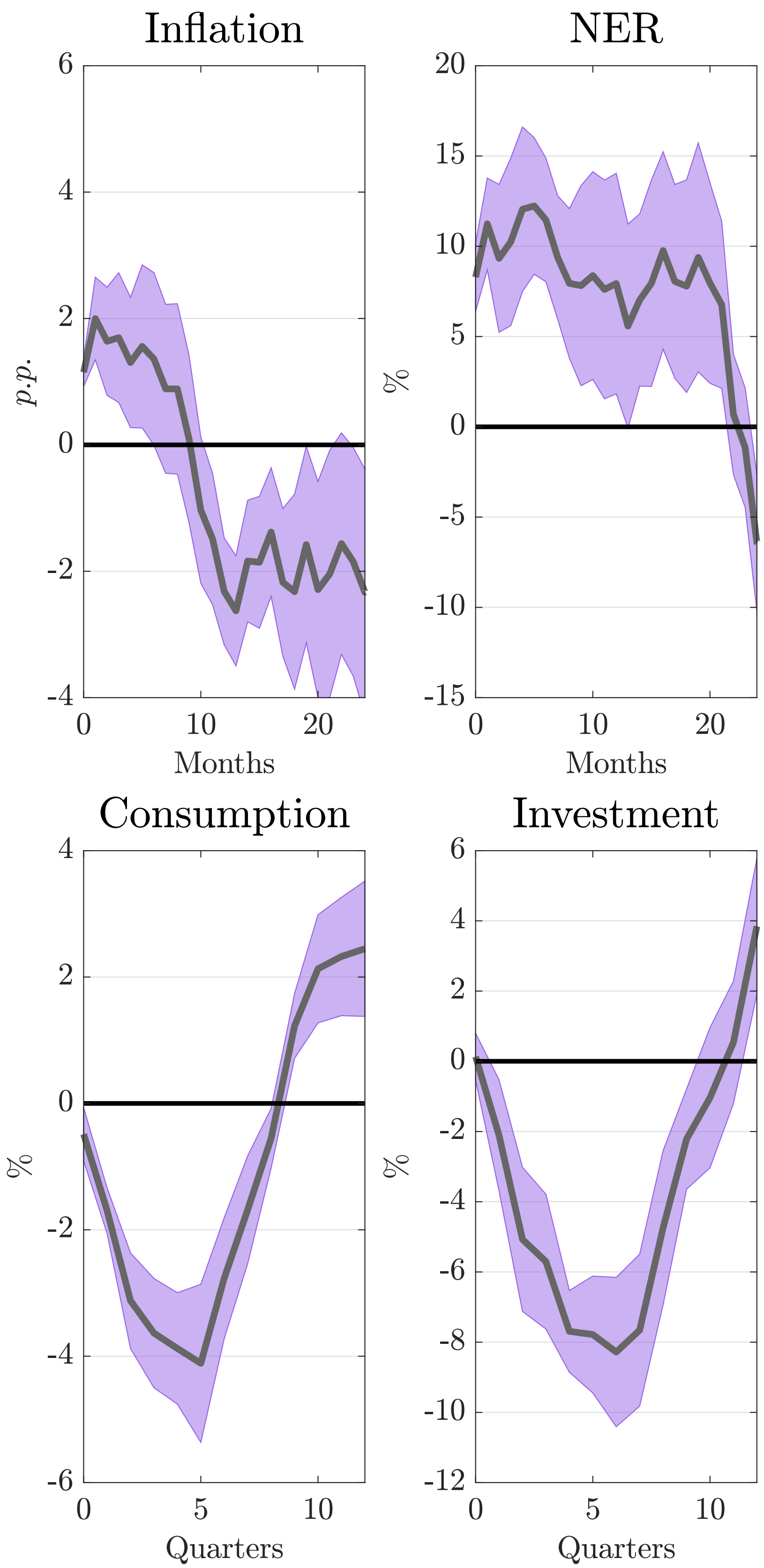
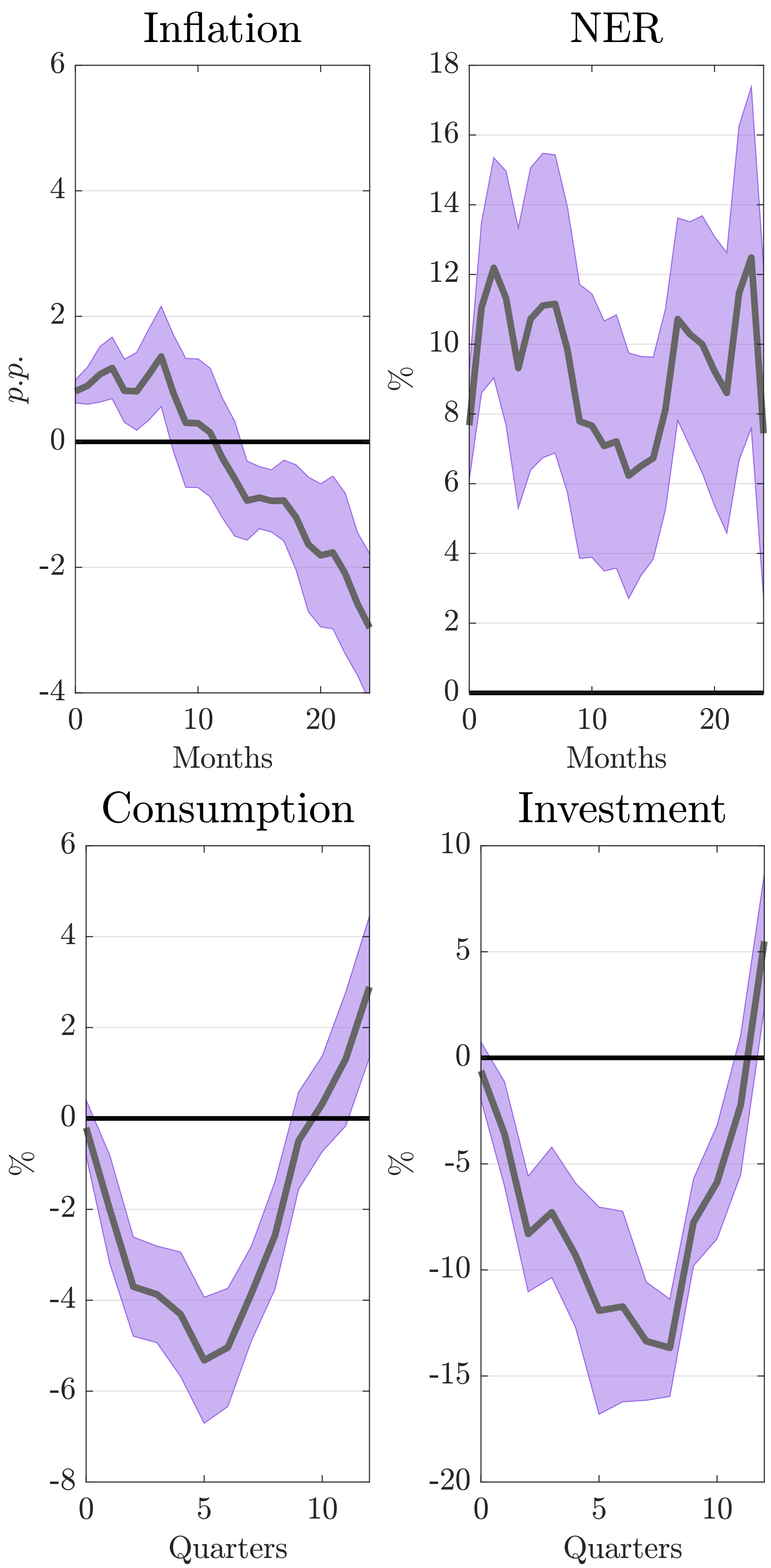


Figure A.2 – Response to 1 std *decline* in price of copper



B Data Details

B.1 Macro Series

COMING SOON

B.2 Micro Databases

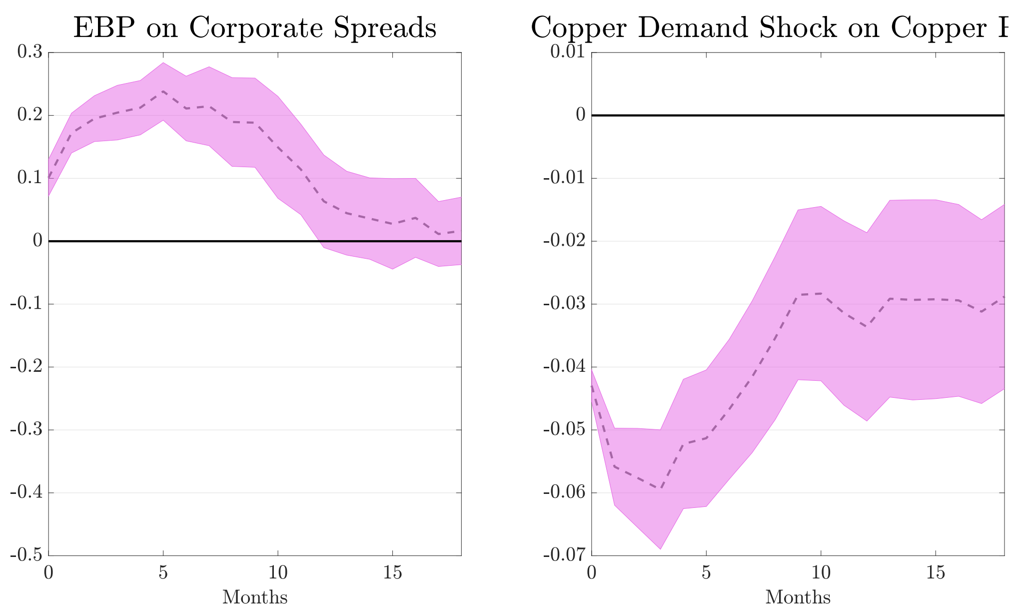
COMING SOON

C Computing Foreign Shocks S_t^*

C.1 First Stage

We run an OLS between the identified shock S_t^* and the domestic variables S_t. Figure C.1 shows the results.

Figure C.1 – First Stage Analysis



Online Appendix: Not for Publication

Contents

A Data: Additional Information

A.1 Data Description

Since 2006, the Chilean Internal Revenue Service demands all formal firms to fill Affidavit N. 1887 (*Declaración Jurada N. 1887*), in which firms have to provide information about every worker that had been employed in the firm the previous year. The firms must report the annual sum of all pre-tax labor earnings paid to each individual and the specific months in which the worker was employed at the firm. This information is used for individuals' tax purposes. The IRS dataset also includes other affidavits that provide information about different firms' characteristics.

In addition, we use the Register Office dataset. It provides a picture of socio-economic characteristics for all individuals living in Chile in 2018.

Variables description. Table A.1 describes the variables used in this article. Worker's variables include the social security number (*Rol Único Nacional, RUN*) and demographics characteristics (gender and date of birth) provides by the Register Office.

Firm's variable include the tax identification number (*Rol Único Tributario, RUT*) and industry. The industry is reported at a country-specific 6-digits classification, which can be aggregated at the 4-digits ISIC rev. 4 classification.

In relation to labor relationship's variables, the dataset provides information about total annual labor income, monthly dummies and total months. Total labor income includes the base salary, incentives and rewards, payments for agreements, sales commissions and overtime payments; it does not include social security payments. Monthly dummies take the value of 1 if the worker was employed at the firm in a given month. In addition, we have information about total number of months the worker was employed at the firm in a given year.

Table A.1 – Variables

Variable	Years in data	Short description	Source
Worker's variable			
Worker identificacion number	2005-2018	Social Security Number (RUN)	IRS
Gender	2018		RO
Date of birth	2018		RO
Firm's variables			
Firm identificacion number	2005-2018	Tax identification number (RUT)	IRS
Industry	2005-2018	4-digits ISIC	IRS
Labor relationship's variables			
Total annual labor income	2005-2018	Nominal in Chilean pesos	IRS
Monthly dummies	2005-2018	1 if the worker is employed at the firm	IRS
Total months	2005-2018	Total months worked in each year	IRS

Sample construction. Table A.2 describes the sample construction.

- Drop observations if labor income is zero or missing.
- Merge IRS data with RO data and drop all workers for whom the Register Office does not provide information.
- Keep only males.
- Drop observations if the worker is younger than 25 or older than 55.
- Drop observations if the total annual labor income is less than 0.5 × minimum wage × total months
- Winsorize wage at p 99.999
- Keep only the highest-paying job in each month

Table A.2 – Data description: Cleaning statistics

Description	**IRS**	
Start date	2005m1	
End date	2018m12	
Total number of date-worker observations	773,066,388	
Average annual number of workers	5,779,546	
Average annual number of firms	264,106	
Cleaning	**Number of Removed Observations**	
	Total	%
Income=0 or income=.	814,702	0.11%
Do not have RO information	14,890,017	1.93%
Female	285,988,010	36.99%
Age <25 or >55	112,297,013	14.53%
Less than minimum wage	11,903,639	1.54%
Not highest-paying job	7,357,296	0.95%
Remaining observations	339,815,711	43.96%