Labor market and systemic risk: a network-based approach

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Abstract

In this paper, we explore the labor market channel of systemic risk. We consider that distressed firms, besides defaulting on part of their debt commitments, also react to negative shocks by laying off part of their employees. This constitutes another source of systemic risk, as these dismissed employees will not be able to honor their debt commitments. Using Brazilian data, we compute the systemic risk considering three possible strategies adopted by distressed firms: layoff of employees, default on debt commitments, or both strategies. We have found, among other things, that the labor market channel of systemic risk cannot be dismissed. Its contribution to the overall systemic risk has increased in the last months and the amplification of initial shocks is higher through this channel than through the firms' loans channel.

Keywords: labor market, systemic risk, complex networks

JEL Classification: D85, E44, G21, G23, G28

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1 Introduction

In this paper, we assess how negative shocks on the labor market – caused by firms' layoff decisions – propagate through the financial system. To our best knowledge, addressing this issue is a novelty. Systemic risk models usually assume that distressed firms default on part of their claims against the financial sector. However, as shown by the recent (as of March 2023) events concerning the tech industry in the U.S., massive layoffs are another strategy adopted by firms in face of unfavorable conditions. These job cuts can affect the financial system through the loans extended to these dismissed employees.

To this end, we developed a network-based model. This approach has proved to be a powerful tool for the analysis of systemic risk in financial systems (Acemoglu et al., 2015; Battiston et al., 2012; Eisenberg and Noe, 2001; Gai and Kapadia, 2010; Nier et al., 2007; Upper, 2011). As in other studies tackling the impact of shocks on the real sector in the financial system (Lux, 2016; Silva et al., 2017, 2018), the nodes of the network are represented by banks and firms. However, in this paper, bank-firm linkages are represented by two layers: the personal loans granted by the bank to the firm's employees, and the corporate loans extended to the firms.

The role of the deterioration in household financial soundness as a driver of economic instability has been already largely documented. Many studies highlighted the importance of shocks to assets held by households. Assuming the nominal value of debt is fixed, a decline in assets' price automatically leads to a reduction in household net worth. A primary consequence of a decrease in household net worth is a decline in consumption. This effect can take place due to many channels, such as precautionary saving (Carroll and Kimball, 1996) and borrowing constraints due to the smaller collateral value (Kiyotaki and Moore, 1997). There are also some frictions, such as the zero lower bound on the nominal interest rate (Eggertsson and Krugman, 2012; Guerrieri and Lorenzoni, 2017; Hall, 2011), which prevents an adjustment in the interest rate and a consequent alleviation in the household borrowing constraints. These theoretical insights are corroborated by some empirical studies. For instance, Mian et al. (2013) found the 2007-2009 housing collapse in the United States caused a sharp decline in consumption. Moreover, this effect is higher for more leveraged households, as debtors tend to be less wealthy than the average and debt concentrates losses on the balance sheet of the debtors.

Other consequences of impairment in household wealth have been explored. (Mian and Sufi, 2014) found the *housing net worth channel* – a deterioration in household balance sheets – was a key determinant of the sharp decline in U.S. employment between 2007 and 2009. This is a secondary effect of the decrease in consumption, caused either by a direct wealth effect or a tightening in the borrowing constraints. Small businesses rely on household collateral for financing more than large firms (Adelino et al., 2015). Hence, they are more affected by negative shocks to assets held by households. Following a slightly different approach, Baker (2018) assesses the impacts of shocks on household income rather than on assets. He employs a comprehensive data set on U.S. households. Households are matched to their employers and shocks to these employers – such as earnings reports, layoff announcements, mergers, acquisitions, and write-offs – are the sources of changes in household income.

He found the elasticity of consumption concerning income is significantly higher in highly-indebted households. Furthermore, the heterogeneity observed among households is primarily explained by borrowing and liquidity constraints.

Our approach is similar to that of Baker (2018), in the sense we are assessing the effects of changes in household income. Moreover, we also match households to their employers, and shocks on household income are driven by employers' layoff decisions. However, our focus is on another deleterious effect of the deterioration of household wealth, which affects directly the financial system: debt default. A plethora of studies has pointed to unemployment as a key determinant of household debt default, considering different types of loans: credit card loans (Agarwal and Liu, 2003), student loans (Looney and Yannelis, 2015), auto loans (Heitfield and Sabarwal, 2004), mortgages (Gerardi et al., 2013), payroll-deducted and non-payroll-deducted personal loans (Alexandre et al., 2018).

In this paper, we employ a thorough Brazilian data set from March 2015 through December 2020. It contains quarterly information on financial exposures and also on institutions' net worth positions. Firms are connected to financial institutions (FIs) through two layers: the loans extended by the FIs to the firms (the firms' layer), and the loans extended to the firms' employees (the employees' layer). On the other hand, FIs are interconnected among them through the interbank market. Firms can adjust to negative shocks by i) defaulting on part of their debt commitments, ii) laying off part of their employees, or iii) adopting simultaneously (i) and (ii). Strategy (i) affects the banks that granted loans to distressed firms. Strategy (ii) also affects directly the banks that granted loans to the dismissed employees, as they will be unable to honor their debt commitments. Other banks can be affected indirectly through the interbank market. The aggregate loss caused by firms' decisions – systemic risk – is computed through the *differential DebtRank* approach (Bardoscia et al. (2015)). We compute the systemic in each of the situations (i)-(iii).

Our results show the firms' layer is more important than the employees' layer as a source of systemic risk. That is, when only the firms' layer is active, the systemic risk is greater than that when only the employees' layer is active. This result is expected, as the amount of loans granted to the firms' employees is smaller than that extended to the firms themselves. Nonetheless, the importance of the employees' layer cannot be dismissed. The increase in the total systemic risk caused by the activation of the employees' layer has become larger in the last periods. Also, an initial shock of a given size will cause a larger aggregate loss to the financial system if transmitted through the employees' layer than through the firms' layer – that is, the shock multiplier of the employees' layer is greater than that of the firms' layer. Finally, we found public FIs, small-sized FIs, and banks are more vulnerable to shocks in the real sector and that credit unions are the only case in which the employees' layer is more important than the firms' layer as a source of systemic risk.

This paper proceeds as follows. The data set and methodological issues are discussed in Sections 2 and 3, respectively. Section 4 brings the results. Finally, final considerations are presented in Section 5.

2 The data set

Our data set comprises quarterly information from March 2015 through December 2020 (24 periods). Based on several unique Brazilian databases with supervisory and accounting data, we build two networks for each of these periods: the bank-bank (interbank) network and the bank-firm bipartite network.

The interbank network considers all types of unsecured financial instruments. They are registered in the Central Bank of Brazil and controlled by different custodian institutions, such as Cetip, the Central Bank of Brazil's Credit Risk Bureau System (SCR), and the BM&FBOVESPA. Credit, capital, foreign exchange operations, and money markets are among the main types of financial instruments. In this network, links are represented by net financial exposures between Brazilian financial institutions (FIs) which meet the following requirements: i) are financial conglomerates or individual financial institutions that do not belong to conglomerates, ii) are classified as "b1", "b2", or "b4" (the extended banking system) or "b3" (credit unions) in the Central Bank of Brazil's classification system, and iii) have positive equity.[1]

In the bank-firm bivariate network, we consider two layers: i) the corporate loans granted by the FIs to the firms, and ii) the personal loans granted by the FIs to the employees of the firms. To build the second layer, we first use the SCR to identify the personal loans granted to households. Then, we use the Annual Report of Social Information (RAIS) to match households to their respective employers. Households who are not employees of any firm are excluded. Finally, we aggregate loans to the firm level. In this network, we include only non-financial firms with positive equity[2] listed on the Brazilian stock exchange (BM&FBOVESPA). FIs are included in this network if they meet the criteria (i) to (iii) specified in the previous paragraph. In Figure 1, one can observe the amount of interbank (IB) loans in our sample is much larger than the aggregate loans extended to the firms and to the firms' employees.

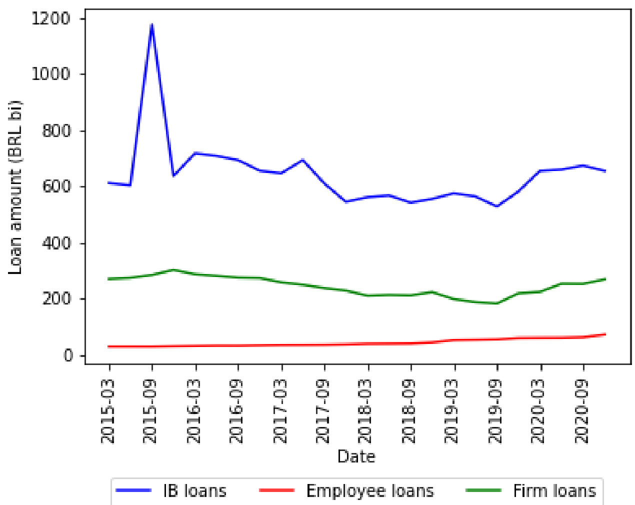

Figure 1: *Loan amount (in BRL billions).*

[1] Financial institutions' equity was retrieved from `https://www3.bcb.gov.br/ifdata`.
[2] Information on firms' equity was retrieved from the *Economatica* database.

3 Methodology

Let us define the exposure matrix $\mathbf{A} \in NB \times (NB + NF)$, where NB is the number of FIs, NF is the number of firms, and A_{ij} is the net exposure of i towards j. Observe that $\mathbf{A}$ results from the combination of both networks – the interbank network and the bank-firm network. Agent i – the creditor – can be only a FI. Agent j – the debtor – can be either a firm or a FI. If j is a firm, A_{ij} is equal to the sum of two components: the corporate loan granted by FI i to firm j (A^F_{ij}), and the personal loan granted by FI i to the employees of firm j (A^E_{ij}). Otherwise, A_{ij} is the loan granted by FI i to FI j in the interbank market.

At period $t = 0$, we impose an exogenous shock on firm j in the form of a loss equal to a fraction ζ of its equity. This leads the firm to lay off a fraction ζ of its employees and default a fraction ζ of its corporate loans. Through the firms' layer, the loss transmitted to FI i is A^F_{ij}. The aggregate loan extended to the employees of j is A^E_j. For simplicity, we assume that FI i has exposure on these dismissed employees equal to ζA^E_{ij}.[3] We also assume that dismissed employees are not able to honor their debt commitments. Therefore, the direct loss transmitted by the employees of firm j to FI i is equal to ζA^E_{ij}. Hence, the total loss transmitted to FI i is $\zeta A^F_{ij} + \zeta A^E_{ij} = \zeta A_{ij}$.

We compute the loss suffered by the financial system as a result of the propagation of this shock following the *differential DebtRank* (Bardoscia et al., 2015) methodology. The dynamics of loss propagation are represented by the following equations:

$$\Delta L_{ij}(t) = min\left(A_{ij} - L_{ij}(t-1), A_{ij}\frac{[L_j(t-1) - L_j(t-2)]}{E_j}\right), \tag{1}$$

$$\Delta L_i(t) = min\left(E_i - L_i(t-1), \sum_j \Delta L_{ij}(t)\right), \tag{2}$$

in which $t \geq 0$. In Eqs. 1 and 2, E_j is the agent j's equity, $L_{ij}(t)$ is the accumulated loss transmitted by j to i up to period t, $\Delta L_{ij}(t) = L_{ij}(t) - L_{ij}(t-1)$ is the new flow of loss transmitted by j to i, $L_i(t) = \sum_j L_{ij}(t)$ is the total loss transmitted to i by their debtors up to t, and $\Delta L_i(t) = L_i(t) - L_i(t-1)$ is the variation in the total loss transmitted to i by their debtors up to t. Note that equity positions and the exposure network $\mathbf{A}$ are exogenous and, hence, time-invariant. Moreover, to avoid double-counting, only loss differentials are considered in the propagation process.

We can describe the loss propagation process as follows: when an agent j suffers an additional loss equal to a fraction ζ of its equity, it will impose a loss to its creditors equal to ζ times their exposures towards j. Remembering that such exposures are formed by the sum of the loans extended to the firm and the firm's employees. There are two restrictions: i) j cannot impose to i a loss greater than i's exposures towards j (Eq. 1), and ii) losses imposed to i cannot be greater than its equity (Eq. 2). When $L_i(t) = E_i$, i stops suffering losses from other agents, as well as propagating losses to other

[3] One can suppose this experiment is run for a sufficiently large number of times. Thus, the average exposure of FI i on the dismissed employees will be equal to ζA^E_{ij}.

agents.

Observe that, at period $t = 0$, there is only the *direct* loss suffered by the FIs with exposures on the distressed firms. For $t \geq 1$, there is the propagation of *indirect* losses, which takes place exclusively on the interbank network. After a sufficiently large number of periods $T \gg 1$, the system converges – that is, no more losses are propagated. We repeat this process for the other firms. In the end, we have the *matrix of vulnerabilities* $\mathbf{V}^{\zeta} \in NB \times NF$, where V_{ij}^{ζ} is the loss suffered by FI i after an initial shock of size ζ on firm j.

4 Results

In this section, we present the results concerning the impact of shocks on the real sector in the financial system. This is done by stressing all the firms simultaneously. After the computation of the matrix of vulnerabilities (Section 3), we compute the *systemic impact* (SI) caused by a shock of size ζ SI_{ζ} according to the following equation:

$$SI_{\zeta} = 100 \times \frac{\sum_i \sum_j V_{ij}^{\zeta}}{\sum_i E_i}, \tag{3}$$

where $j = \{1,...,NF\}$ refers to the set of firms and $i = \{1,...,NB\}$ is the set of FIs. Therefore, SI_{ζ} measures the percentage of the aggregate equity of the financial system which is lost after the firms lost a fraction ζ of their net worth. The *systemic vulnerability* (SV) of FI i is equal to

$$SV_{i,\zeta} = 100 \times \frac{\sum_j V_{ij}^{\zeta}}{E_i}, \tag{4}$$

where $j = \{1,...,NF\}$. Thus, $SV_{i,\zeta}$ is the fraction of equity that FI i would lose, on average, if all firms lost a fraction ζ of their net worth. We consider three levels of the initial shock ζ (0.1, 0.5, and 1.0) and three situations: i) only the firms' layer is active, ii) only the employees' layer is active, and iii) both layers are active. In case (i), firms will default a fraction ζ of their debt commitments. In case (ii), firms will lay off a fraction ζ of their employees. Finally, in case (iii), both strategies will be adopted.

The aggregate results are depicted in Figure 2. As expected, the losses are larger for higher values of ζ. The total impact is considerably larger than the direct impact, which means the losses caused by the contagion in the IB market are considerable. There was a decrease in the aggregate impact in the last periods, mainly for smaller levels of ζ, mainly caused by a decrease in the impact due to the firms' layer. The impact caused by the firms' layer – that is, when only the firms' layer is active – is larger than that caused by the employees' layer.

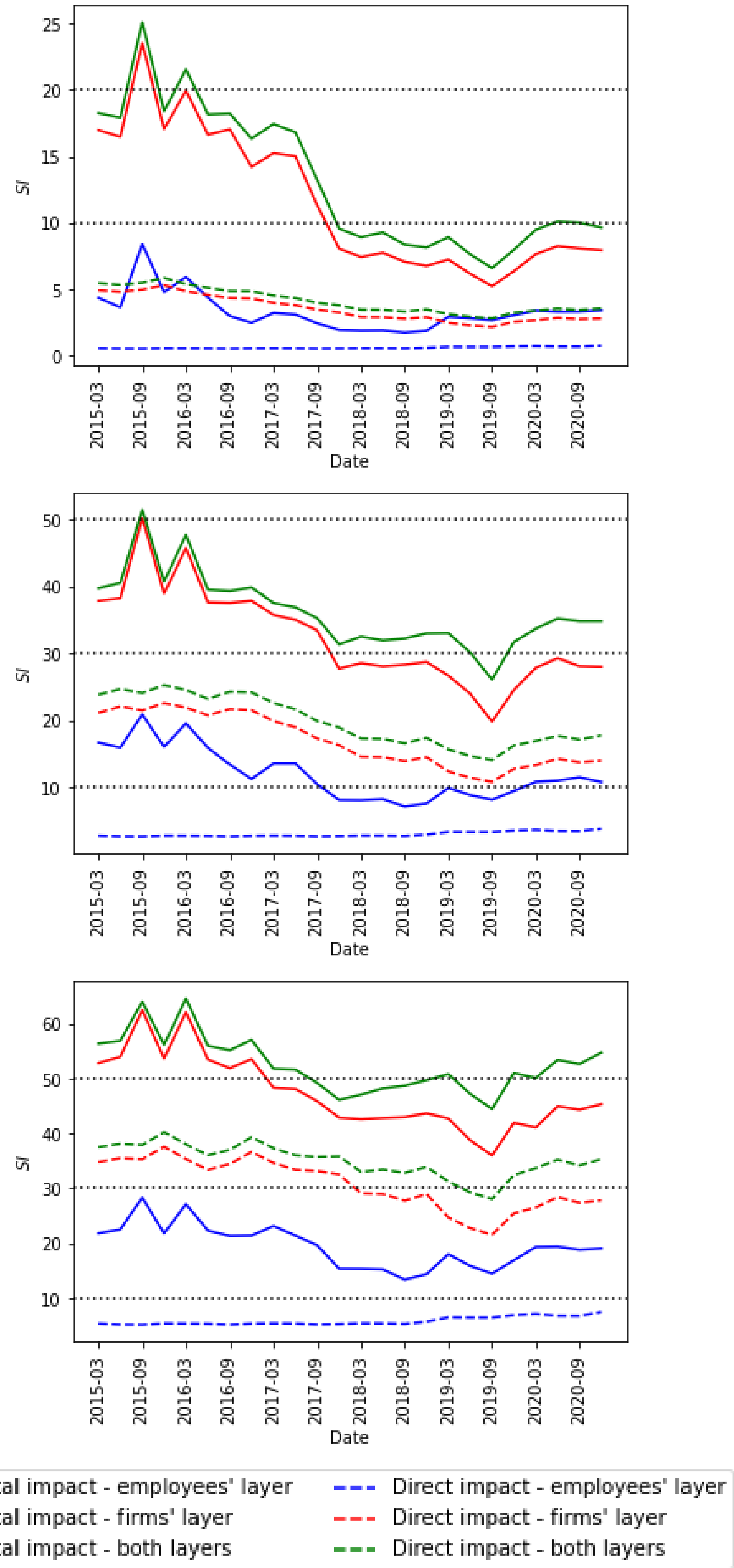

Figure 2: *Direct and total impact, aggregate, for* $\zeta = 0.1$ *(top),* $\zeta = 0.5$ *(center), and* $\zeta = 1$ *(bottom).*

Despite the impact caused by the employees' layer is smaller than that caused by the firms' layer, the increase in the total impact brought by the activation of the employees' layer rose in the last periods (Figure 3). For instance, in March 2015, for $\zeta = 0.1$, the aggregate impact jumped from 16.97% (when only the firms' layer is active) to 18.25% after the activation of the employees' layer – an increase of 7.5%. In December 2020, this increase was 21.5%.

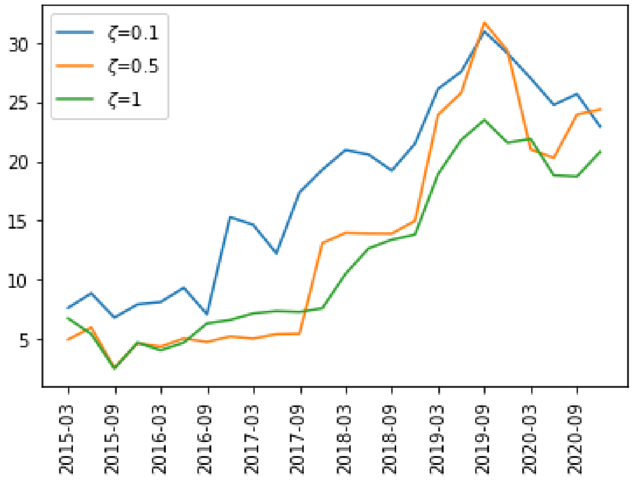

Figure 3: *Increase in the total systemic impact brought by the activation of the employees' layer (in %).*

The higher impact caused by the firms' layer is mainly due to the larger amount of loans extended to the firms compared to those extended to the firms' employees (Figure 1). Hence, to compare the shock propagation throughout both layers, we performed a slightly different exercise. We computed the systemic impact for both layers by imposing direct shocks of an equal amount. After suffering a loss equal to a fraction ζ of its net worth, the firm i will impose to FI j a loss equal to $\zeta' A_{ij}$, where

$$\zeta' = \zeta \times \frac{E_i}{\sum_j A^l_{ij}}. \tag{5}$$

In the equation above, $l = \{F, E\}$. Thus, the aggregate direct impact $\sum_j \zeta' A_{ij}$ will be equal to ζE_i for both layers F and E. Finally, we define the *shock multiplier* of layer l as the total systemic impact-to-direct impact ratio. If there is no contagion, the total impact is equal to the direct impact and the shock multiplier is equal to 1.

As shown in Figure 4, the shock multiplier of the employees' layer is higher than that of the firms' layer. It suggests the adjustment through layoffs made by distressed firms will cause a higher impact on the financial system than that caused by the adjustment through corporate loan default.

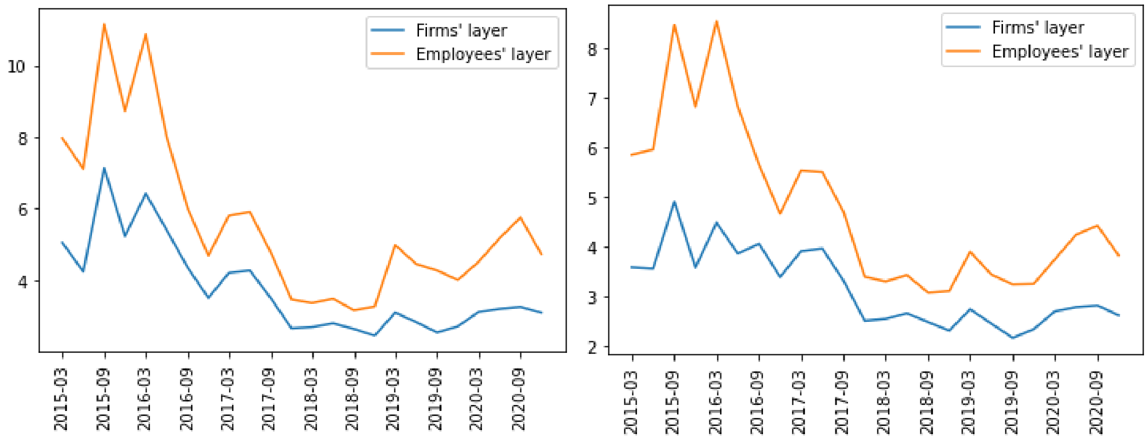

Figure 4: *Layers' shock multiplier, for* $\zeta = 0.01$ *(left), and* $\zeta = 0.02$ *(right).*

Figures 5-7 depict the average systemic vulnerability weighted by the FIs' equity, grouped according to different criteria. In general, public FIs, small-sized FIs, and banks are more vulnerable to shocks in the real sector. Under a high level of the initial shock (ζ=1), FIs of different sizes are equally affected by the shock. For credit unions, the employees' layer is at least as important as the firms' layer regarding the loss caused to this segment, being the former more important than the latter when ζ=1.

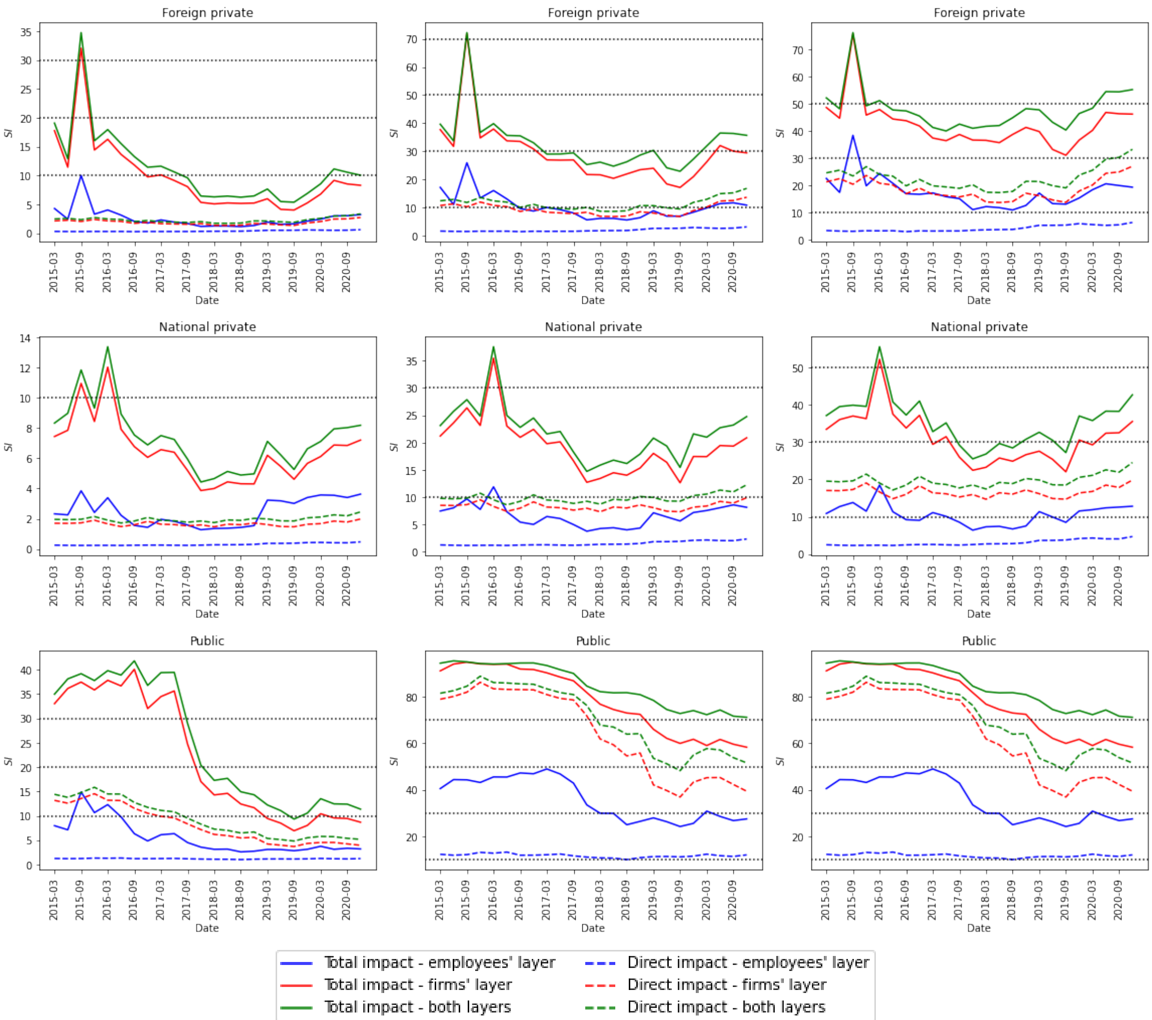

Figure 5: *SV by control, for $\zeta = 0.1$ (left), $\zeta = 0.5$ (center), and $\zeta = 1$ (right).*

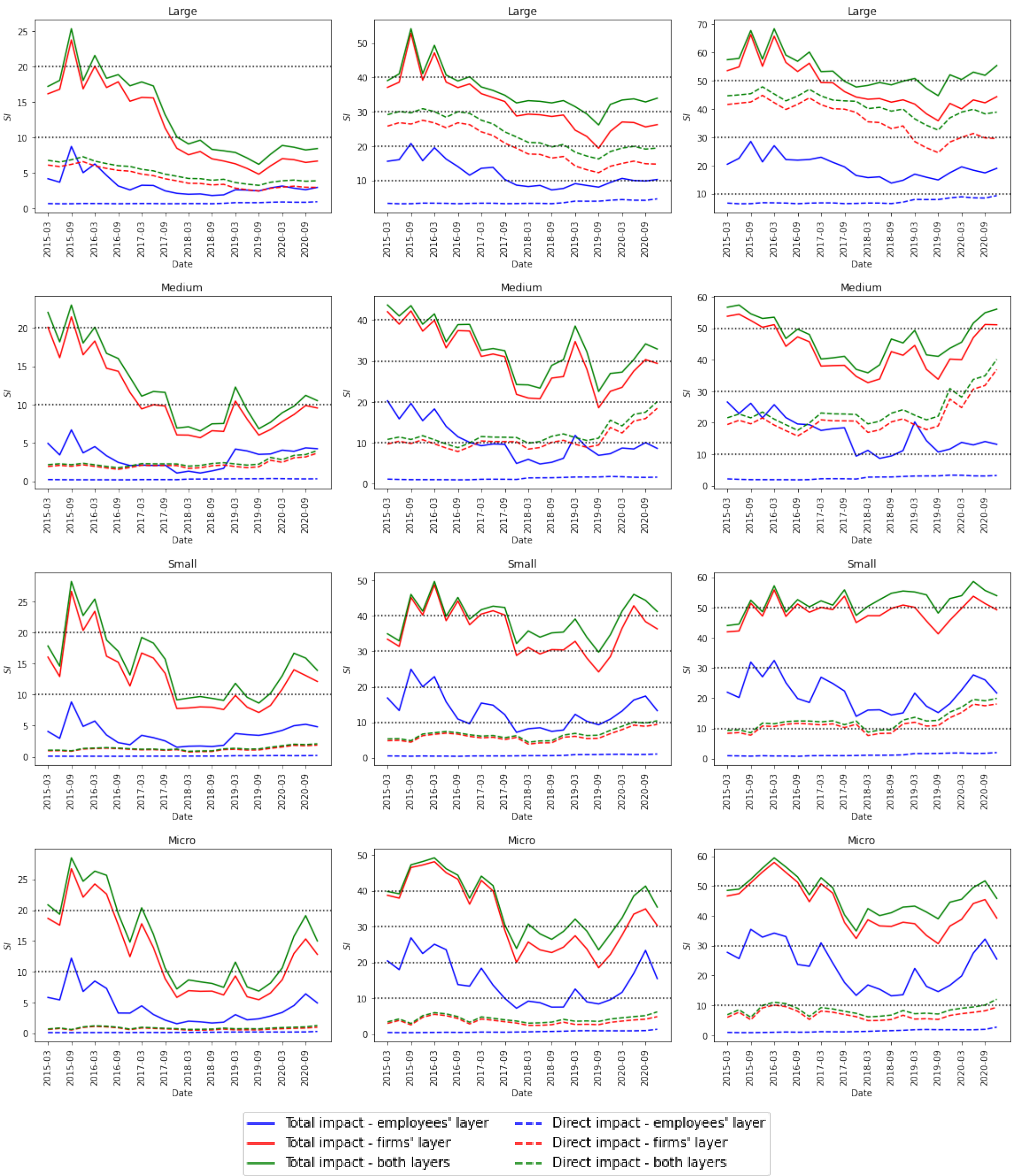

Figure 6: *SV by size, for* $\zeta = 0.1$ *(left),* $\zeta = 0.5$ *(center), and* $\zeta = 1$ *(right).*

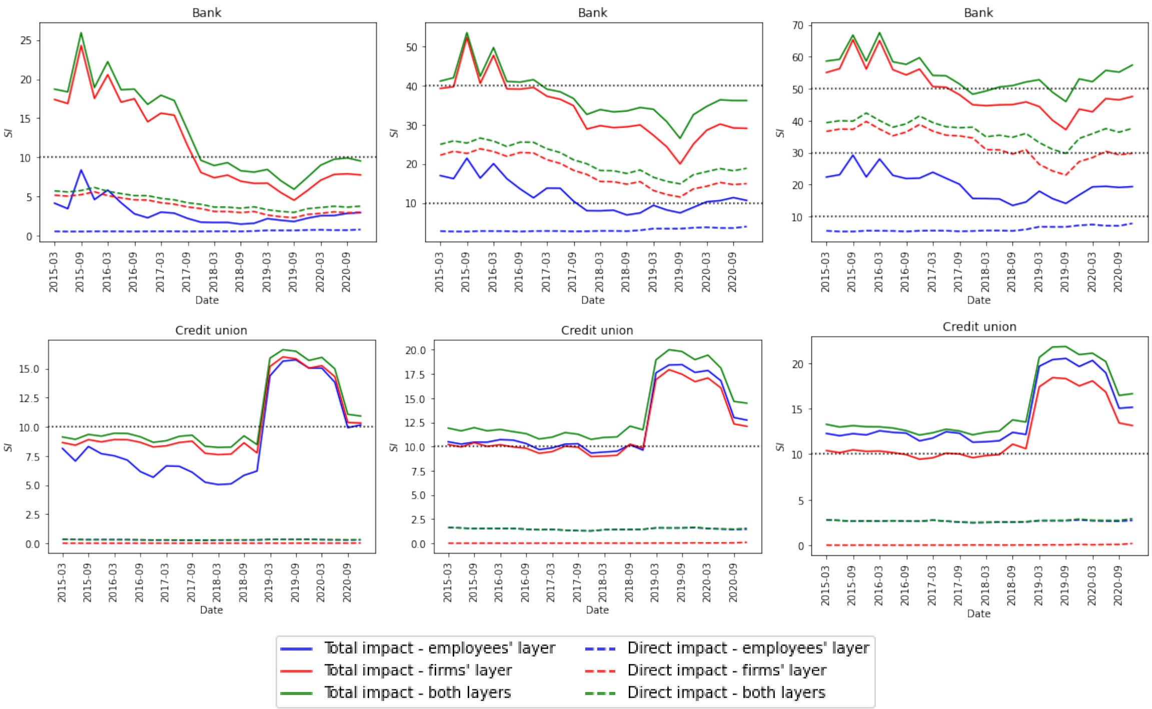

Figure 7: *SV by type, for $\zeta = 0.1$ (left), $\zeta = 0.5$ (center), and $\zeta = 1$ (right).*

5 Concluding remarks

In this paper, we assessed the hitherto unexplored labor market channel of systemic risk. Besides defaulting on part of their debt commitments – as usual in network-based models of systemic risk –, distressed firms adjust to negative shocks by laying off a share of their employees. This configures an additional source of financial stability, as the dismissed employees will not be able to fully honor their debt commitments against the financial system.

In our model, distressed firms can react to negative shocks through only one of the two possible strategies – default on their debt commitments or layoff their employees – or adopting both of them. Relying on an extensive Brazilian data set, we computed the systemic risk in each one of the three situations: i) only the employees' layer is active, ii) only the firms' layer is active, and iii) both layers are active. In situation (i), distressed firms lay off part of their employees, who will be unable to honor their debt commitments against the financial institutions. In situation (ii), distressed firms default on part of their debt commitments. In situation (iii), both strategies are adopted by distressed firms. In every case, this initial shock will propagate and will be amplified through the interbank market.

Our main conclusions are the following: i) the importance of the employees' layer as a source of systemic risk is smaller than that of the firms' layer. This is mainly explained by the smaller amount of loans granted to the firms' employees than to the firms themselves. ii) However, the increase in the total systemic risk caused by the activation of the employees' layer has grown recently. iii) Moreover, the shock multiplier of the employees' layer is greater than that of the firms' layer. It means an initial shock of a given size will cause a larger aggregate loss to the financial system if transmitted through the employees' layer than through the firms' layer. iv) Public FIs, small-sized FIs, and banks are more vulnerable to shocks in the real sector. v) Credit unions are the only case in which the employees' layer is more important than the firms' layer as a source of systemic risk.

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