The Role of the Informal Sector in the COVID Crisis: A Cushion or an Amplifier?*

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August 20, 2022

Abstract

Labor informality, common in Latin American economies, is both a cause of low productivity and vulnerability, and a buffer that mitigates job destruction after negative shocks. During the COVID-19 pandemic, informality is also associated with a higher risk of contagion, thus reducing the willingness of households to get involved in informal activities. To understand and quantify the effect of these mechanisms on the economy during the health crisis, we propose a SIR model featuring a dual labor market, where households imperfectly substitute informal and formal consumption, and calibrate it to Colombian and Peruvian data. Considering a higher risk of contagion from the informal sector increases the size of the recession, whereas having less rigidities in markets allows for a faster recovery. Targeting transfers and using selective lockdowns have best epidemiological effect as its non-targeted counterparts, but at a lower economic cost.

Keywords: Informality, Covid, crisis, consumption.

JEL Codes: E21, E24, E26, E32.

*Corresponding author email: ja.zambrano@uniandes.edu.co. Fist version November 22nd, 2020. We thank the Inter-American Development Bank for funding the project. We also acknowledge the comments from Ana Maria Ibañez, Andy Neumeyer, Oliver Azuara, Gustavo Leyva and Carlos Urrutia, as well as participants of seminars at IADB, IMF, Fedesarrollo, Universidad de Antioquia and Universidad de los Andes. Remaining errors are ours.

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1 Introduction

Employment in developing countries has a big component of informality. This makes workers' income more fragile to business cycles and their consumption more volatile given the lack of access to social protection. Informal labor markets are, however, generally more flexible than formal markets. The absence of controls and regulations, and its flexibility, allows informal employment to absorb part of the destruction of the formal sector in presence of negative economic shocks (Leyva and Urrutia (2020)). However, Leyva and Urrutia (2022) have documented an initial decrease in informality, stronger than the one observed for formal labor, during the beginning of the COVID pandemic for five Latin American countries, highlighting the specificity of the crisis and the challenges for a faster recovery. In this paper, we argue the pandemic led to a deeper depression of the informal sector because households perceived a greater risk of contagion from participating in it. However, it also recovered faster than the formal sector, and, by the end of the first wave, it returned to pre-pandemic levels, unlike the formal sector. We seek to understand and quantify these countervailing mechanisms to study the role of informality in the recovery of developing countries from the COVID crisis and evaluate different public policies that can accelerate such recovery within this framework.

The COVID crisis destroyed a considerable amount of formal employment in countries where, beyond informal workers, firms are small and unable to face long periods of illiquidity. Other crises have shown that the informal labor market absorbs an important part of the formal employment destruction with ambiguous consequences for long-term growth (Colombo et al., 2019)). On the one hand, the informal employment allows for a quicker recovery of consumption demand (at least partially) and acts as a form of income insurance for workers in absence of formal welfare networks. On the other hand, informal jobs are less productive and mainly related with low value-added sectors, leading to a low-quality recovery, and hindering long-term growth rate (Ulyssea, 2018).

Another important feature of informality, directly related with the COVID crisis, is the difficulty it has to comply with biosecurity protocols. By definition, informal activity is not subject to public surveillance and the informal worker is not protected against occupational risks. Moreover, the informal sector features more occupations requiring more physical contact and its workers have a lower ability to work from home (Alfaro et al., 2020). This leads to a higher exposure to contagion when participating in the informal sector, as documented by Laajaj et al. (2021). The perception of an increased risk of participating in the informal sector leads households to decrease the demand for informal goods and workers to avoid working in it.[1] Both reactions, in turn, decrease the ability of the informal sector to lead the recovery from the crisis.

To understand the effect of these mechanisms, we propose a model composed of a continuum of households

[1]That households voluntarily lower their economic activity when facing the risk of contagion during the pandemic has been documented by Maloney and Taskin (2020).

and a representative formal firm, embedded within an epidemiological structure. There is a formal and an informal sector in both the goods and the labor market. Households demand both types of consumption goods, which are imperfect substitutes, and are endowed with one unit of indivisible labor and a productivity drawn from a known distribution. Households can be either formally employed in the formal firm to produce formal goods or producing informal goods by their own.

The representative formal firm produces the formal good with a linear technology that aggregates the productivity of its workers, pays a minimum wage and the corresponding payroll taxes to each one of them, and faces hiring costs. We assume a zero-profit condition for the formal firm, thus the firm hires all workers whose productivity is greater than a threshold in such a way that the average productivity is equal to the average real cost of an employee, that is the real wage plus the payroll taxes and the hiring cost, if applicable. As in Hansen (1985), the remainder of households work in the informal sector with a chosen probability and are unemployed with the complementary probability. The household chooses these probabilities in order to maximize its expected utility. As a result of the lottery, unemployed households enjoy the same income as informal workers.[2]

Economic agents interact in a risky environment where they can contract a contagious disease. To model this, we embed the production economy within an epidemiological (SIR) model as in Eichenbaum et al. (2021). Households can be susceptible to an epidemiological virus, infected with it or recovered from it. Those recovered do not have a risk of becoming infected again.[3] Those Infected can recover, die, or remain Infected, and their productivity decreases as a consequence of the illness. Susceptible households can become infected with a probability that increases with the number of infected people, the amount of formal and informal goods demanded and the labor provided in both the formal and the informal sector. The risk of contagion from interaction in the informal sector is higher, following the approach suggested by Krueger et al. (2020).

We calibrate the model to Colombian and Peruvian data to provide a comparison of two developing countries with different structures in their economy that generated differences in their economic performance and their epidemiological results. Informal goods have more weight in the Peruvian consumption bundle. In terms of the labor market, the Peruvian economy has a higher share of informality but a lower minimum wage relative to average informal income, as well as lower payroll taxes, when compared to Colombia, suggesting a worse productivity distribution. Both governments have also differed in their policies and relative targeted lump sum transfers have been lower for Peruvian households.

[2]Our simple approach on the informal labor market is therefore frictionless. There are recent advances on search and matching frictions with formal and informal labor, as in Haanwinckel and Soares (2021), which development within a SIR structure is left for future work.

[3]Or at least are immune while they are vaccinated since our focus is on the first wave.

The model provides rich dynamics on the amount of susceptible, infected, recovered and dead agents; as well as aggregate consumption and employment. The model replicates quite well the observed dip in both economies, including unemployment. Considering a different risk of contagion for informal economies increases the size of the recession and slows recovery when compared to the standard calibration of Eichenbaum et al. (2021) since households imperfectly substitute large amounts of informal consumption for smaller amounts of formal consumption. Having sticky prices deepens the fall in aggregate consumption since the lack of demand during the crisis pushes down the relative price of the formal good. The analysis suggests that flexible prices and a less distorted labor market are key for a faster recovery.

The pandemic generates an equilibrium that is not socially optimal due to the lack of internalization of the impact on the spread of the virus by infected people. Our framework allows us to seek for potential policies that increase the welfare of this economy. Among the policies that we evaluate are selective and general lockdowns, universal and targeted transfers to unemployed and informal workers, and combinations of these policies. We show that providing transfers reduces the size of the recession since households have more income to increase their consumption. The difference between both countries is explained by the relative higher transfers implemented in Colombia and the less distorted labor market in Peru. We also show that targeting transfers to informal and unemployed households have the same epidemiological effects as universal transfers. Although universal transfers generate a small gain in formality by encouraging more spending, the size of the gain is not enough relative to its cost.

Lockdowns were used by governments as another tool to ease the toll of the pandemic. Our analysis shows that lockdowns are specially useful at the beginning of the pandemic lowering economic activity and, therefore, the rate of contagion. However, our results suggest that in epidemiological terms, selective lockdowns to the informal sector are better than generalized lockdowns because they encourage formality where there is a lower risk of contagion. Additionally, it is important to point out that, after a couple of months, when contagion is close to its peak, agents in the economy behave very similarly whether facing a lockdown or not, consistent with the evidence provided by Maloney and Taskin (2020) and Goolsbee and Syverson (2021). This suggests the inconvenience of long and strong lockdowns, as Assenza et al. (2020) have shown theoretically and Cakmaklı et al. (2021) have shown computationally for open economy emergent markets.

The use of SIR models within macroeconomics has been pioneered by Eichenbaum et al. (2021), Alvarez et al. (2021) and Atkeson (2020). Thereafter, several papers have analyzed the optimality of quarantine policies. Among them, Glover et al. (2020) and Acemoglu et al. (2021) have argued in favor of targeted lockdowns in presence of age-heterogeneity. We propose a multi-sector model as in Krueger et al. (2020) and exploit the informality margin to target the lockdown.

Hevia and Neumeyer (2020) propose a small open economy model within an SIR structure to understand the effects of Covid on the labor market on developing countries. They model informality as a fixed proportion of hand-to-mouth agents, as opposed to formal workers who have access to international financial markets. In contrast, we let informality be endogenous and allow for unemployment in our model.

The closest to our proposed model is Alon et al. (2020). They consider formal and informal labor for aggregate production, where individuals sort out depending on their productivity. They evaluate age-specific lockdown policies constraining the formal, but not the informal sector. Although we abstract from the age composition of the economy, we allow for substitution between the informal and formal goods as a mechanism to reduce contagion. Our model is also richer on the possible policies a government can take to alleviate the economic shock beyond lockdowns, including policies that specifically target the informal sector.

Leyva and Urrutia (2022) analyze the impact of the Covid crisis on the labor market for five Latin American countries, documenting an initial decline in the informality rate. They rationalize their results in an RBC model and identify the recession with labor supply shocks and sector-specific productivity shocks to the informal sector. In contrast, our model includes an epidemiological component that endogenously generates the aggregate shock over time that explains the initial decrease in informality.

Kandoussi and Langot (2020) developed a multi-sectoral matching model with heterogeneous workers according to their educational level. They find a differentiated impact of the pandemic on the unemployment rate depending on the worker's qualification degree, as well as a strong persistence of unemployment due to matching frictions. On the other hand, Alfaro et al. (2020) examine the role of informality for recovery considering the IO linkages across sectors in Colombia and their exposure to the lockdown shock, in the spirit of Guerrieri et al. (2022). We deviate from these papers, ignoring heterogeneities across industrial sectors, but instead focusing on the heterogeneity derived from household decisions to obtain a demand for goods of the formal and informal sector. Our approach generates a slower recovery given the risk the households perceive from buying informal goods.

2 Setup

Our framework follows Krueger et al. (2020) and considers a multi-sector economy that we identify with formal and informal markets. The time is discrete and the horizon is infinite. There is a continuum $j \in [0, 1]$ of individuals maximizing the objective function:

$$V = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t^j, n_t^j\right)$$

Where $\beta \in (0,1)$ is the discount factor, c_t^j denotes the consumption for individual j, n_t^j denotes the hours worked for individual j , and $U(.)$ is an increasing, concave and differentiable function. The expectation $\mathbb{E}_0$ is taken with respect to the possible future health status that we describe below.

Consumption c_t^j is an aggregator of formal and informal consumption with elasticity of substitution $\eta \geq 1$. Let c_{tf}^j be the consumption of formal goods and c_{tl}^j the consumption of informal goods, and let γ_k, for $k = l, f$, be the weight of the (in)formal good on the composite bundle:

$$c_t^j = \left(\gamma_f {c_{tf}^j}^{1-\frac{1}{\eta}} + \gamma_l {c_{tl}^j}^{1-\frac{1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

The individual can work in the formal or the informal sector. We consider the framework proposed by Hansen (1985) where labor is indivisible and each household must decide whether to exclusively work in the formal n_{tf}^j or informal sector n_{tl}^j, or to remain unemployed u_t, with $n_{tf}^j + n_{tl}^j + u_t = 1$. Each household j is born with a productivity A^j for the formal sector that is drawn from a cumulative distribution $G(A)$. There is a representative formal firm that hires formal labor at a minimum wage w_t, pays payroll taxes τ for all employees, pays hiring costs κ whenever it hires new employees,[4] and transforms labor into a formal good with price P_{tf}. Its production function is linear and aggregates the productivity of its workers: $y_{tf} = \int A^j n_{tf}^j \, dj$. Therefore profits Π_t each period can be expressed as:

$$\Pi_t = P_{tf} \int \left[A^j - w_t \left(1 + \tau + I_\kappa \kappa \right) \right] n_{tf}^j dj$$

where I_κ is an indicator of whether the firm is hiring any worker or not.

We assume the formal sector hires high productivity workers until its profits become 0. Therefore, there exists a threshold $\hat{A}$ such that the formal firm hires all the workers with productivity $A^j \geq \hat{A}$, where $\mathbb{E}\left[A | A > \hat{A} \right] = \frac{w_t(1+\tau+I_\kappa \kappa)}{P_{tf}}$.

In the informal sector all individuals have the same productivity. They produce with their own technology in that sector, which follows a linear production function $y_{tl}^j = n_{tl}^j$. Let the price for the informal good be normalized to 1, which will be equal to the wage earned for working in the informal sector.

The population is divided in four groups: the susceptible with mass S_t, who may contract the disease but are not currently infected, the infected with mass I_t, the recovered who become immune to the disease with mass R_t, and the dead with mass D_t. We assume the risk of becoming infected for the susceptible depends

[4] Our approach here is to assume that hiring new workers leads to a cost for every employee in the firm. One can think on a training cost that affects everyone and we calibrate it accordingly.

on consumption and labor choices. Let π_t be the probability of type s to become infected, it is defined as:

$$\pi_t = I_t \left(\pi_{c_l} c^s_{tl} c^i_{tl} + \pi_{c_f} c^s_{tf} c^i_{tf} + \pi_{n_l} n^s_{tl} n^i_{tl} + \pi_{n_f} n^s_{tf} n^i_{tf} + \pi_0 \right)$$

Where π_{c_k} is a parameter determining the infection risk from consuming in sector $k = f, l$, with $\pi_{c_l} > \pi_{c_f}$. Similarly, π_{n_k} is a parameter describing the infection risk when working in sector k, with $\pi_{n_l} > \pi_{n_f}$. Finally, π_0 is the baseline probability of contagion even if individuals do not consume or work. Let the total number of newly infected people be given by $T_t = \pi_t S_t$. Following Eichenbaum et al. (2021), infected people have a decrease in productivity ψ, reflecting the expected effect of the illness.

The dynamics of the four groups evolves as follows:

$$S_{t+1} = S_t - T_t$$

$$I_{t+1} = I_t + T_t - (\pi_d + \pi_r) I_t$$

$$R_{t+1} = R_t + \pi_r I_t$$

$$D_{t+1} = D_t + \pi_d I_t$$

$$M_{t+1} = M_0 - D_t$$

Where π_d is the probability of death for an infected individual, π_r is the probability of recovery of an infected person, and M_t denotes the mass of individuals at time t. We assume that initial conditions are $I_0 = \epsilon$, $S_0 = 1 - \epsilon$, and $R_0 = D_0 = 0$.

3 Recursive formulation

As described before, households with a productivity $A^j \geq \hat{A}$ choose to work in the formal sector. The remainder portion of households, $G(\hat{A})$, choose a lottery such that with probability α the agent works in the informal sector $n_l = 1$ and with probability $1 - \alpha$ they remain unemployed, as in Hansen (1985). In this case, regardless of the intertemporal elasticity of substitution of labor and assuming a separable function, the utility function is defined as:

$$U(c_t, n_t) = \log c_t - \theta \alpha_t$$

for those that do not qualify for the formal sector[5]. The budget constraint of a household with productivity A^j is expressed as:

$$P_{tf}c_{tf}^j + c_{tl}^j \leq I_{A^j \geq \hat{A}} w_t n_{tf}^j + \alpha_t^j \tag{1}$$

where $\alpha_t^j n_{tf}^j = 0$ since participation in each sector is mutually exclusive.

We now represent recursively the problem for each type of individual. Let v^s be the value function for susceptible individuals, v^i the value function for infected, v^r the value function for those recovered and normalize the value function for dead individuals to $v^d = 0$.

The problem to be solved by a susceptible, infected and recovered individual, respectively, is:

$$v^{sj}(P) = \max_{c_f^s, c_l^s, n_f^s, \alpha^s} \log c^s - \theta n_f^s - \theta \alpha^s + \beta \left[(1-\pi)v^s + \pi v^i\right]$$

$$v^{ij}(P) = \max_{c_f^i, c_l^i, n_f^i, \alpha^i} \log c^i - \theta n_f^i - \theta \alpha^i + \beta \left[(1-\pi_d-\pi_r)v^i + \pi_r v^r\right]$$

$$v^{rj}(P) = \max_{c_f^r, c_l^r, n_f^r, \alpha^r} \log c^r - \theta n_f^r - \theta \alpha^r + \beta \left[v^r\right]$$

subject to budget constraint (1).[6]

Note that we are assuming away the possibility of reinfection. This is a simplifying assumption consistent with the analysis of the first wave of COVID and does not affect the results of the model or the policy implications.

For susceptible individuals the first order condition with respect to the consumption of good $k = f, l$ is:

$$\gamma_k \left(\frac{1}{c^s}\right) \left(\frac{c^s}{c_k^s}\right)^{\frac{1}{\eta}} = \lambda_b^s P_k + \beta \left(v^s - v^i\right) I \pi_{c_k} c_k^i$$

Where λ_b^s denotes the Lagrange multiplier corresponding to the budget constraint of a susceptible individual. Note that the risk of infection associated with the consumption of good k, the second term of the right-hand side, decreases the amount of consumption when compared to a world without pandemics. Since the risk of infection is greater for informal consumption, its demand will decrease relatively more in the peak of infection, a key mechanism for our results.

For low productivity workers, the decision with respect to α is also distorted by the risk of infection,

[5]For those willing to work in the formal sector we assume the marginal disutility of working is also θ, so there is no distortion in the threshold $\hat{A}$ since the probability of infection from working in the formal sector is lower than the one from working in the informal one.

[6]In addition to the changes that agents may experience from susceptible to infected and from infected to recovered, there may be changes from the informal to the formal sector and vice versa. However, these changes are captured in the budget constraint, through the relative price of the formal good P.

thus they will reduce more their informal labor supply the greater their marginal probability of becoming infected:

$$\lambda_b^s = \theta + \beta \left(\upsilon^s - \upsilon^i\right) I \pi_{n_l} \alpha^i G\left(\hat{A}\right)^2$$

On the other hand, decisions for infected and recovered households are not distorted. The marginal rate of substitution for each type of consumption and for $h = i, r$ is:

$$\gamma_k \left(\frac{1}{c^h}\right) \left(\frac{c^h}{c_k^h}\right)^{\frac{1}{\eta}} = \theta P_k$$

Note that for these types of individuals the risk of infection is no longer relevant. However, since the two sectors, formal and informal, do not have the same prices, an infected individual will not necessarily distribute her consumption evenly between the formal good and informal good.

4 Public policy experiments

In our model, we simulate four public policy experiments. The first public policy exercise refers to the payment of lump sum transfers, where we simulate three scenarios; the first, in which the transfer is paid to the entire population, the second with a targeted transfer to informal workers and unemployed, which in our model refer to the mass $G\left(\hat{A}\right)$, and the third corresponds to the previous scenarios but increasing the size of the lump sum transfers.

The second public policy experiment is intended to assess the impact of lockdowns in economic and epidemiological variables. One way to model this type of situation is through consumption taxes, as Eichenbaum et al. (2021) does. To do this, the impact of a generalized lockdown is simulated through a tax on the consumption of the formal good and the informal good in our model.

The previous exercises imply a modification of the budget constraint 1 of an agent j, in such a way that it would be now defined as:

$$(1+\mu)\left(P_{tf} c_{tf}^j + c_{tl}^j\right) \leq I_{A^j \geq \hat{A}} w_t n_{tf}^j + \alpha_t^j + T \tag{2}$$

where μ is the consumption tax and T is the lump sum transfer.

The third exercise seeks to simulate the impact of a selective lockdown on the informal sector, a situation that in our model we address by setting a consumption tax only on the informal good, with which the budget

constraint of an agent j will be determined by:

$$P_{tf}c_{tf}^{j} + (1+\mu)c_{tl}^{j} \leq I_{A^j \geq \hat{A}} w_t n_{tf}^{j} + \alpha_t^{j}$$

The fourth experiment consists on lowering payroll taxes to decrease the tax burden for formal firms.

5 Calibration

We calibrate the model to Colombian and Peruvian economies to highlight the differences implied by each economic structure. The Peruvian economy has a less distorted labor market since its minimum wage for formal workers is close to the median informal wage and payroll taxes are also lower. However, the typical Peruvian consumption bundle has a higher share of informal goods and their informality rate is higher.

Table 1 summarizes the chosen values for parameters and their source. The impatience parameter β is standard in the literature. The elasticity of substitution between sectors is set to 10 and is chosen according to Krueger et al. (2020). We performed additional exercises for different values; however, elasticities above 5 do not generate substantial differences on the results. The weights for formal and informal goods are chosen to represent conservative approximations to the share of goods bought in informal markets.[7] The labor disutility parameter θ is calibrated to generate 40 weekly working hours. The productivity of infected people ψ follows Eichenbaum et al. (2021) and we calculate its contribution to the recession in Tables 2 and 7 for Colombia and Peru, respectively.

The relative formal wage w is calculated as the official hourly minimum wage relative to the median hourly informal wage according to the 2019 national surveys ENH and GEIH. Payroll taxes are taken from OECD. The productivity distribution is approximated with an exponential distribution and its parameter is chosen to match the formal employment given the calibrated formal wage and the corresponding payroll taxes.[8] The hiring costs were calculated as an increase in the cost to every employee of the firm. We follow the estimate of Muehlemann and Leiser (2018) of pre-hiring costs to calibrate κ, adjusting for the hazard rate of becoming employed in the formal sector given the amount of current formal employees, given our formulation of the firm problem. For the latter, we use the maximum increase in formal employment observed

[7] The biggest centers for contagion in Peru were informal markets since most households rely on them to do their daily shopping. Several consumer behavior surveys show Peru is, with Bolivia, the country with the largest share of the traditional retail channel (small proximity shops, open food markets, etc) in South America. While Colombia is one of the countries with the fastest growth in the share of online shopping, in recent years. The Kantar World Panel 2015 estimates the traditional channel share in 68% of the total expenditure in Peru, while it is 53% in Colombia. Furthermore, according to The National Household Surveys for Colombia and Peru (GEIH and ENH, respectively), while 52.5% of Peruvian households have a refrigerator, that number is 84% for Colombian households. This fact generates a need for Peruvian households to visit markets more often.

[8] Formality is defined as suggested by the International Labor Organization (ILO) to have comparable measures between Peru and Colombia, since the Colombian National Department of Statistics (DANE) follows a different definition that leads to a lower rate of formality. Our metric closely follows the homogeneous estimations for both countries in Fernández et al. (2017), see table 2, page 142.

in Janueary 2021, as shown in Figure 13. The resulting hiring cost is thus 12% of a minimum wage.

The government transfers given during the crisis are also expressed relative to the median hourly informal wage, these have been higher for Colombia than for Peru. Finally, the epidemiological parameters follow on average the ones suggested by Eichenbaum et al. (2021) but a spread between the formal and the informal sector is calibrated to reproduce the contagion rates documented by Laajaj et al. (2021), who found that informal workers where more affected by contagion. We also report in Tables 2 and 7 the results for the calibration suggested by Eichenbaum et al. (2021), assuming the formal and informal sector have the same risk of contagion.

Table 1: Calibration.

Parameter	Colombia	Peru	Description	Source
β	$0.96^{\frac{1}{52}}$	$0.96^{\frac{1}{52}}$	Discount factor	Eichenbaum et al. (2021)
η	10	10	Elasticity of substitution	Krueger et al. (2020)
γ_f	1.2	0.8	Formal good weighting in consumption aggregator	Match relative expenditure weight
γ_l	0.8	1.2	Informal good weighting in consumption aggregator	Match relative expenditure weight
θ	0.0276	0.0276	Labor supply parameter	Match unemployment rate: DANE, INEI
ψ	0.8	0.8	Productivity of infected people	Eichenbaum et al. (2021)
w	1.26	1.07	Hourly minimum wage relative to median hourly informal wage	GEIH, ENH
τ	0.3	0.175	Payroll taxes	OCDE
κ	0.12	0.12	Hiring costs	Muehlemann and Leiser (2018)
λ	1.88	1.28	Exponential distribution for productivity	Match formal employment
T	13.68	8.15	Weekly lump sum transfer relative to median hourly informal wage	DNP, MEF
π_0	0.3902	0.3902	Autonomous Infection Intensity	Eichenbaum et al. (2021)
π_{c_l}	1.9602×10^{-7}	1.9602×10^{-7}	Infection risk from consuming - Informal sector	Match Laajaj et al. (2021) data
π_{c_f}	7.8408×10^{-8}	7.8408×10^{-8}	Infection risk from consuming - Formal sector	Match Laajaj et al. (2021) data
π_{n_l}	3.1105×10^{-4}	3.1105×10^{-4}	Infection risk from work - Informal sector	Match observed data
π_{n_f}	1.2442×10^{-4}	1.2442×10^{-4}	Infection risk from work - Formal sector	Match Laajaj et al. (2021) data
π_d	2.3333×10^{-4}	2.3333×10^{-4}	Death rate	Match Laajaj et al. (2021) data
π_r	0.2331	0.2331	Recovery rate	Match Laajaj et al. (2021) data

6 Results

We first report the results for Colombia along with the figures representing the epidemiological and economic path of the baseline calibration and the simulated policies. We then present the quantitative results for Peru comparing them with those for Colombia. We omit the figures for Peru since they are qualitatively similar to Colombia's.

6.1 Colombia

Figure 1 shows the epidemiological path implied by the baseline calibration compared to that obtained with the calibration suggested by Eichenbaum et al. (2021) where there are no differential risks of contagion across sectors. The results show that considering a differential risk increases the peak of the pandemic because of the relative size of the informal sector and its greater risk of contagion. The dynamics of the infection

generates an endogenous size of the shock that affects consumption and labor decisions. The higher the number of infected people, the riskier it is to participate in economic activities.

Figure 2 shows that aggregate consumption falls[9] 5.9% in our baseline calibration, compared to 4.04% for the case where there is no differential risk of contagion. This adjustment occurs mainly in the consumption of the informal good (-6.7%), which is partially substituted for formal consumption.

In fact, Figure 2 shows that the drop in informal consumption is bigger than for formal consumption when there is a differential risk, which in turn generates a greater drop in aggregate consumption and a surge in unemployment (Figure 3). Even though there is substitution towards the formal good, there is also a fall in its demand because it also entails a nonneglibible risk of contagion. This leads to a decrease in the price of the formal good that also decreases employment in the formal sector, although in a lower magnitude when compared to the change in the informal employment.

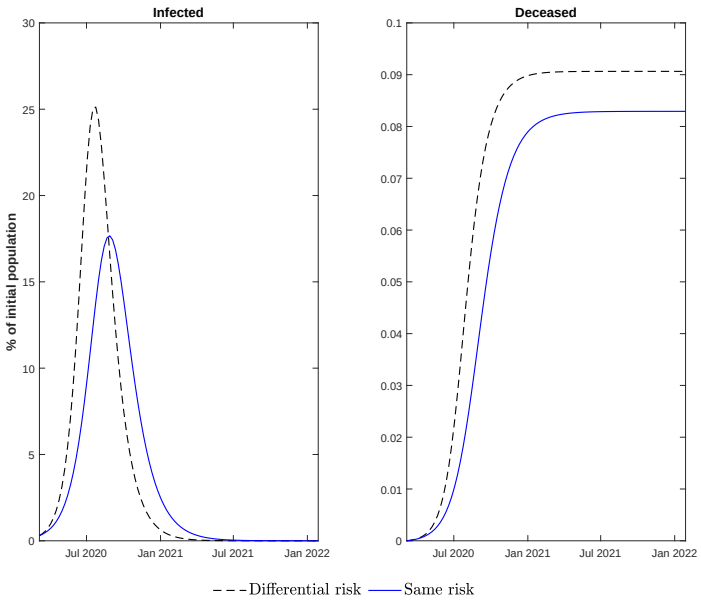


Figure 1: Epidemiological results

The results for the labor market mirror the previous ones. While both formal and informal employment decreases, Figure 3 shows a bigger drop in informal employment, decreasing from 55% to 49%. Formal employment also decreases because the lack of demand depresses the price of the formal good, thus increasing the real wage. The fall in the formal price is higher when there is a differential risk of contagion generating a bigger fall in formal employment. The drop in formal employment is likely to be bigger because firms face dynamic costs such as liquidity and contracting problems, which we abstract in our simpler model. Lost

[9]These figures correspond to the maximum drop, not the annual drop.

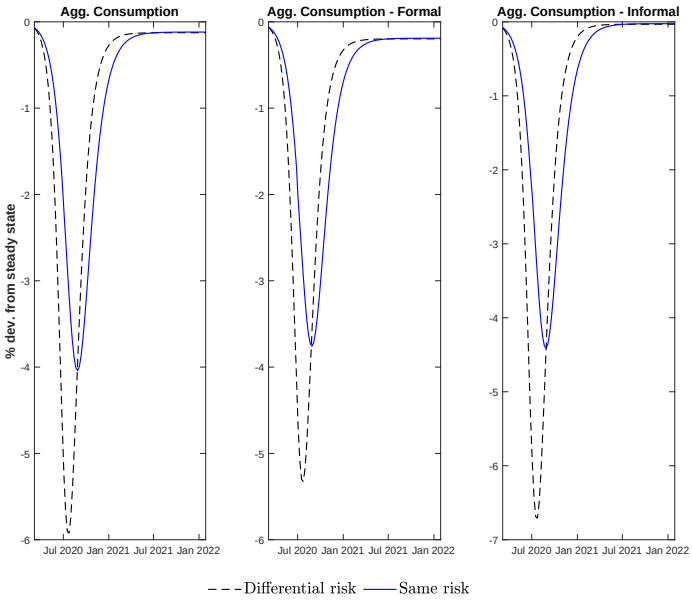


Figure 2: Consumption

employment is absorbed by unemployment since there are no margins left in the model, increasing it in 6 percentage points.[10]

Table 2 presents the aggregate results of the pandemic in terms of annual fall of aggregate consumption, the maximum unemployment rate and the amount of deceased individuals. The baseline calibration for Colombia suggests an annual fall of -1.81% and a maximum unemployment of 15.48%, while the deceased sum up to 0.09% of the population.[11] In a scenario of sticky prices, where the formal price does not adjust, the fall in aggregate consumption is even bigger because formal consumption drops even more, and the number of deceased agents remains the same because it is harder to substitute informal consumption. Considering a differential risk of contagion increases the size of the recession by almost 0.3pp given the large drop in informal employment, and also increases the number of fatalities due to the higher risk of contagion in the informal sector. Finally, if there is no drop in the productivity of infected people, there is a lower impact on the aggregates.

In the following subsections, we explore the role of public policies to smooth the pandemic. We first describe the results for targeted and non-targeted transfers. Afterwards, we evaluate the consequences of targeted and non-targeted lockdowns.

[10] Actually, there was an important increase in inactivity as shown in Leyva and Urrutia (2020) which is captured by our increase in unemployment. In fact, our unemployment numbers should be interpreted as the unemployment rate plus the new inactives, fixing the prepandemic inactive rate.

[11] These statistics are similar to those of Carranza et al. (2020), who include initial immunity as a mechanism to rationalize the observed recession.

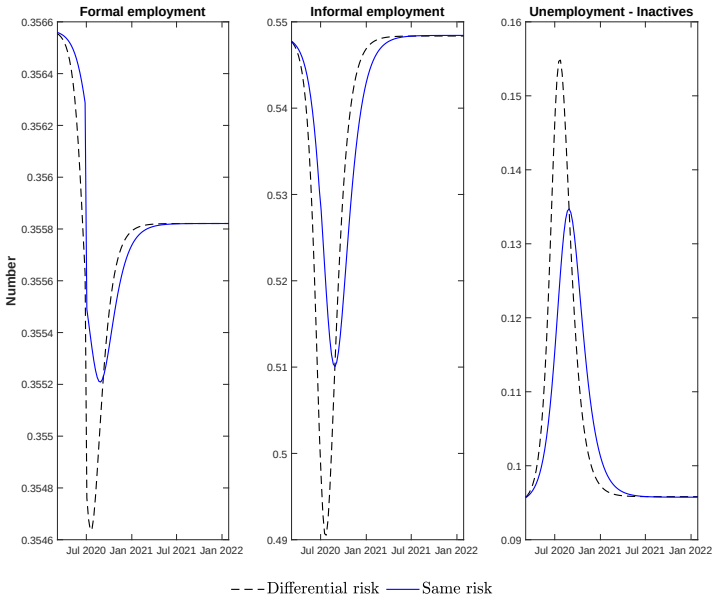


Figure 3: Employment

Table 2: Baseline results - Colombia.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-7.00%	34.37%	0.0759%
Baseline	-1.81%	15.48%	0.0906%
Without reduction in productivity of infected people	-0.26%	10.61%	0.0907%
Same probability of infection in both sectors	-1.58%	13.47%	0.0829%
Sticky prices	-1.83%	15.52%	0.0906%

6.1.1 Lump sum transfers

One of the most widely used public policy to alleviate the crisis generated by the pandemic are lump sum transfers to households. These transfers stimulate demand by increasing households income and decrease labor supply as people are more willing to stay at home if they have an unconditional income that helps them meet their needs. Figure 4 shows that transfers are successful at slowing the speed of the pandemic, the effect being more important the greater the transfers. Remarkably, the effect of targeted transfers is the same as the effect of universal ones.

Figure 5 shows that universal transfers generate a smaller fall in the consumption of formal goods. This fall is lower as the amount of the transfer is greater. This smaller fall in the consumption of formal goods drives up its price, so the formality rate does not fall as much. However, although universal transfers reduce the drop in the consumption of informal goods, a higher value does not have a significant impact. This implies a smaller fall in aggregate consumption with respect to the baseline, but not a significant difference in the fall

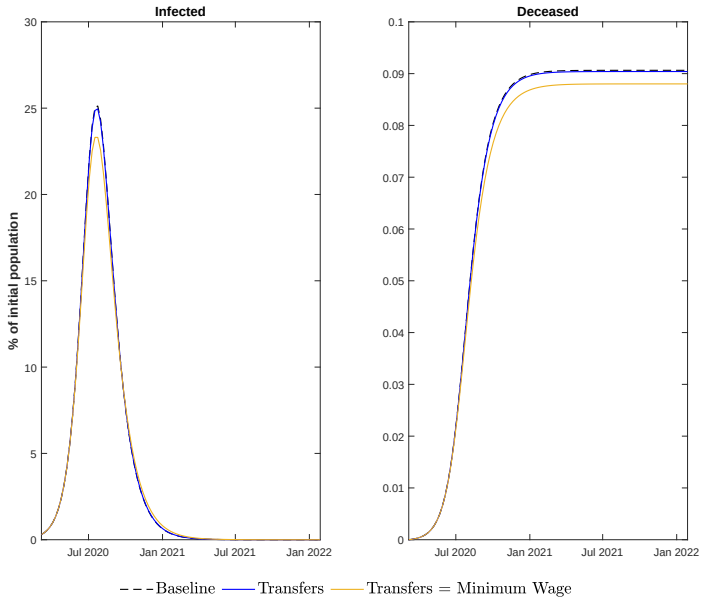


Figure 4: Epidemiological results - Lump sum transfers.

when comparing it to the effect of a transfer equivalent to the minimum wage. Were the transfers equivalent to a minimum wage, the increase in unemployment would have been 11 percentage points relative to the baseline because individuals have less incentives to be exposed to the virus. This in turn is 10 percentage points more than the unemployment generated by the calibrated transfers, as shown in Figure 6, thus the transfers created by the Colombian government did not have a significant impact on the labor market.

We also perform different exercises increasing the value of universal transfers until reaching a value equivalent to the minimum wage to better understand its income effect. As shown in table 3, multiplying generalized transfers by 4 times generates a smaller drop in aggregate consumption of 0.24 pp with respect to the baseline scenario due to the compensatory effect generated by the transfers. However, with transfers of a magnitude greater than 5 times the calibrated level, the fall in consumption reverses its downward path due to the considerable increase in inactivity, 9 pp above the level observed in the baseline scenario. A similar exercise, but looking at targeted transfers, is considered in the Appendix and maintains the qualitative implications.

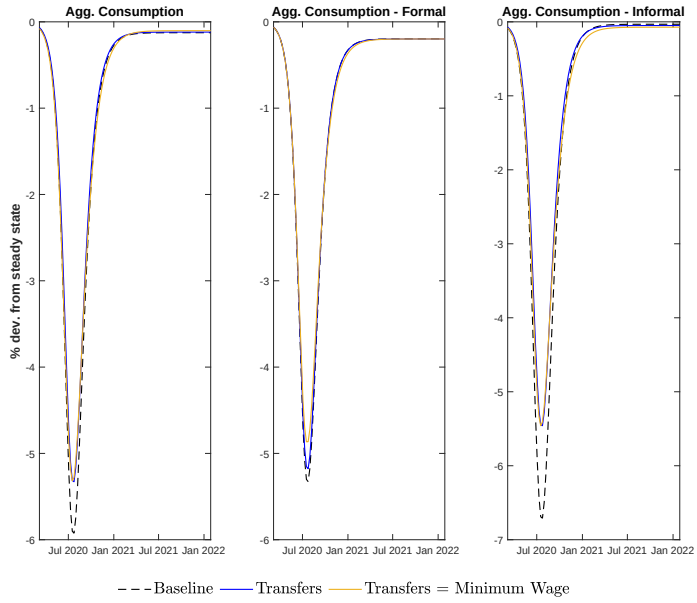


Figure 5: Consumption - Lump sum transfers.

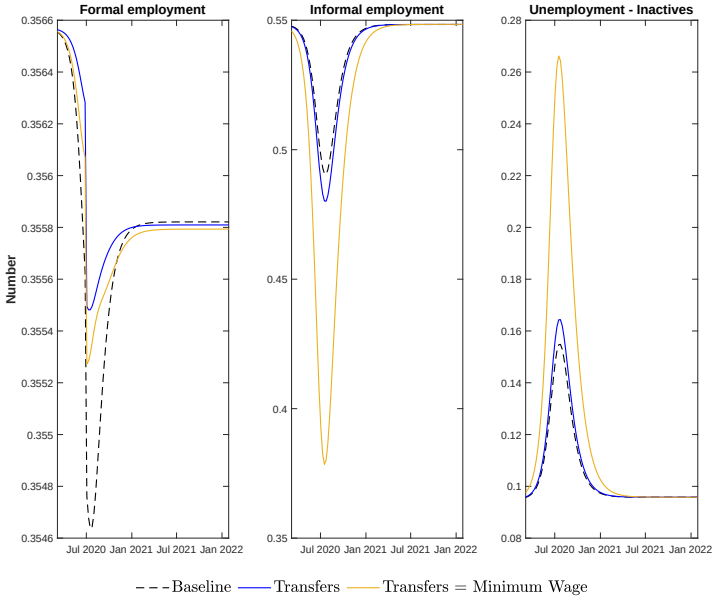


Figure 6: Employment - Lump sum transfers.

6.1.2 Lockdowns

Governments have also used lockdowns as a tool to slow agents interactions and smooth the peak of the pandemic. They have been particularly useful to prevent the saturation of ICU beds, which was proven to be

Table 3: Lump sum transfers results - Colombia.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-7.00%	34.37%	0.0759%
Baseline	-1.81%	15.48%	0.0906%
Lump sum transfers	-1.64%	16.43%	0.0904%
Lump sum transfers x 2	-1.56%	17.70%	0.0901%
Lump sum transfers x 3	-1.54%	19.29%	0.0897%
Lump sum transfers x 4	-1.57%	21.22%	0.0892%
Lump sum transfers x 5	-1.65%	24.43%	0.0885%
Lump sum transfers: equivalent to minimum wage	-1.73%	26.61%	0.0880%

key to reduce the fatalities in the US (Bravata et al. (2021)). Although we abstract from the availability of ICU beds, lockdowns in our model are useful in reducing the transmission of the infection in early stages as they decrease consumption by making it more costly. In our analysis we consider generalized lockdowns and selective lockdowns on the informal sector. Following Eichenbaum et al. (2021), to simulate the consequences of the generalized and selective lockdown, we perform computational exercises with the consumption tax set to 0.5 and 1. In the next subsection, we calibrate it to reproduce the observed labor market outcomes.

Generalized lockdown cause a considerable drop in the consumption of formal and informal goods, with the effect being particularly high in the informal sector, which in the end generates a greater drop in aggregate consumption, as shown in Figure 8. Additionally, as seen in Figure 9, generalized lockdowns have a considerable effect on the labor market, particularly on formal and informal employment. Although unemployment and inactivity increase slightly as the lockdown is more intense, the results suggest a strong recomposition between formality and informality. The lockdown generates an increase in the price of the formal good, reducing its demand and, in equilibrium, production. This reduction in labor supply means that less people can work in the formal sector and, therefore, they must move to the informal sector.

As a consequence of this flow of workers from the formal sector to the informal sector, the results of the epidemiological variables worsen with generalized lockdowns as is shown in Figure 7. This occurs because there is a higher percentage of the population in the informal sector, where the probability of contagion is greater, increasing the number of infected and deceased people compared to the baseline. The result argues against long lockdowns, which can also have other costs such as decreasing individual liberties. Moreover, generalized lockdowns greatly affects formal consumption, preventing the effective substitution of informal for formal consumption.

On the other hand, selective lockdowns in our model are only imposed on the informal sector. As shown in Figure 10, in this case there are positive epidemiological results since the percentage of infected and deceased people is reduced. This occurs because, unlike the generalized lockdown, in this selective lockdown

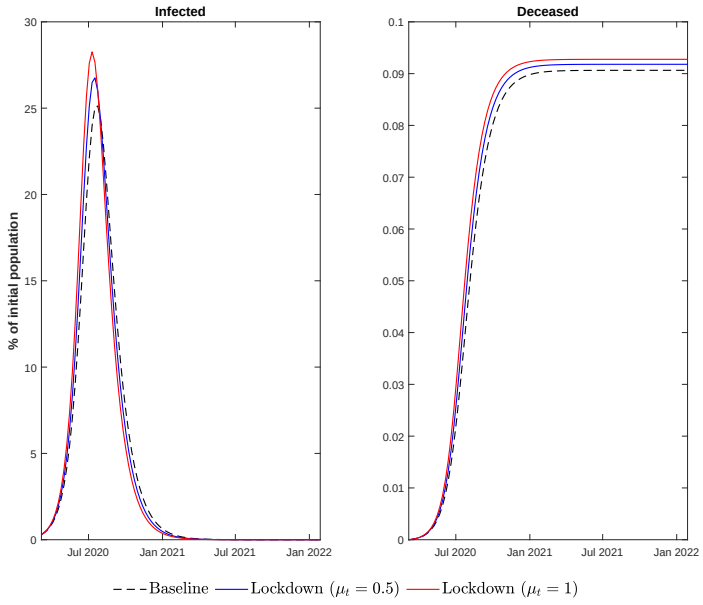


Figure 7: Epidemiological results - Lockdown.

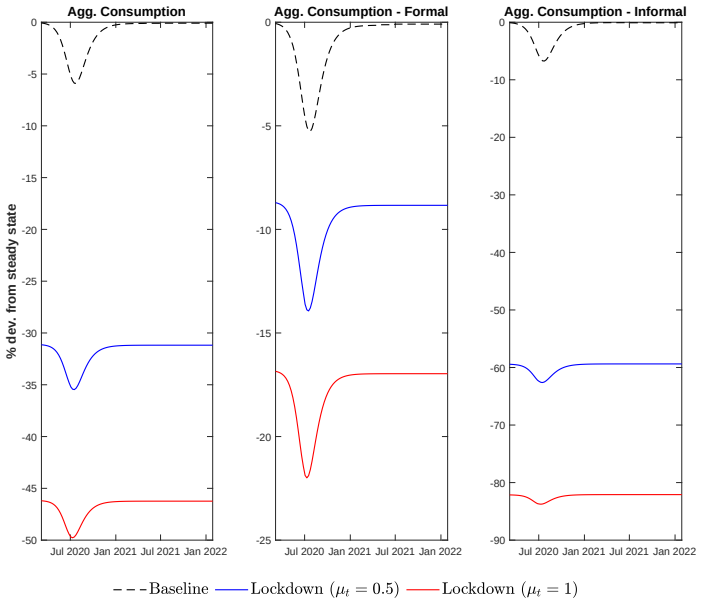


Figure 8: Consumption - Lockdown.

scheme there is a substitution effect between the consumption of formal and informal goods. As the price of the informal good increases relatively and due to the greater risk of contagion in this sector, the demand for the formal good increases, with which its price increases and so does production, as shown in Figure 11.

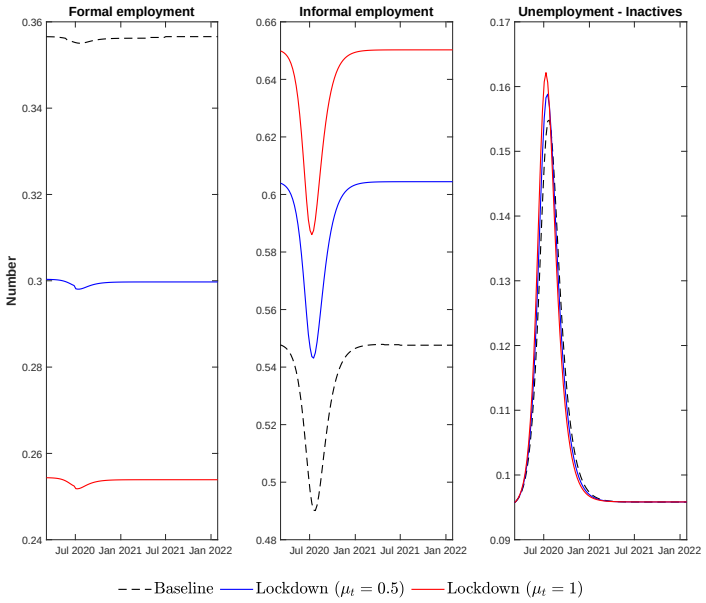


Figure 9: Employment - Lockdown.

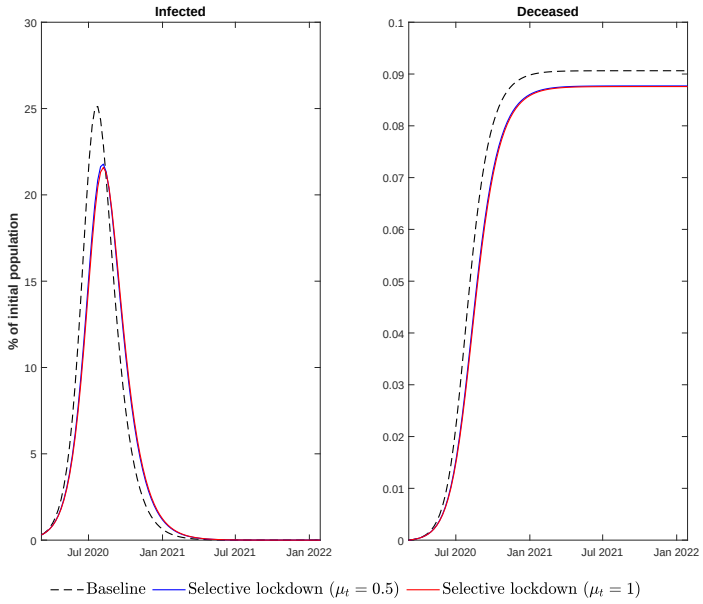


Figure 10: Epidemiological results - Selective Lockdown.

The increase in production in the formal sector causes an increase in formality due to a flow of workers from informality and unemployment and inactivity as shown in Figure 12, thus potentially generating long term gains. These results show that selective lockdowns are superior in epidemiological and economic terms

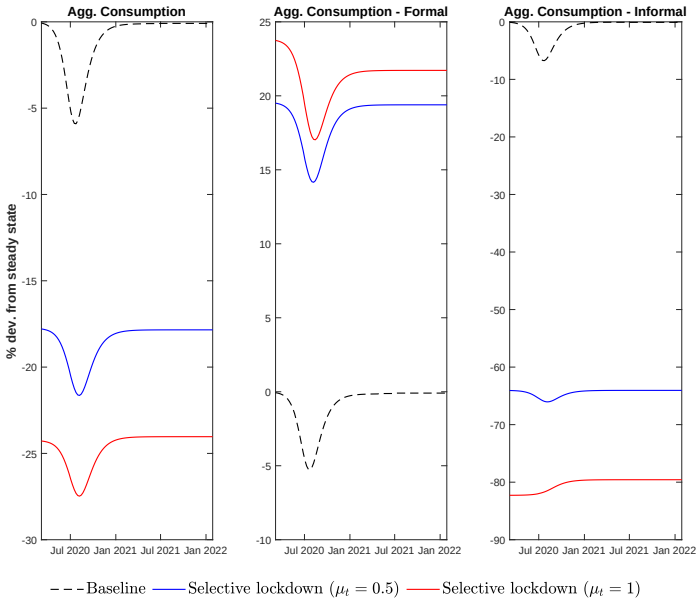


Figure 11: Consumption - Selective lockdown.

to generalized lockdowns.

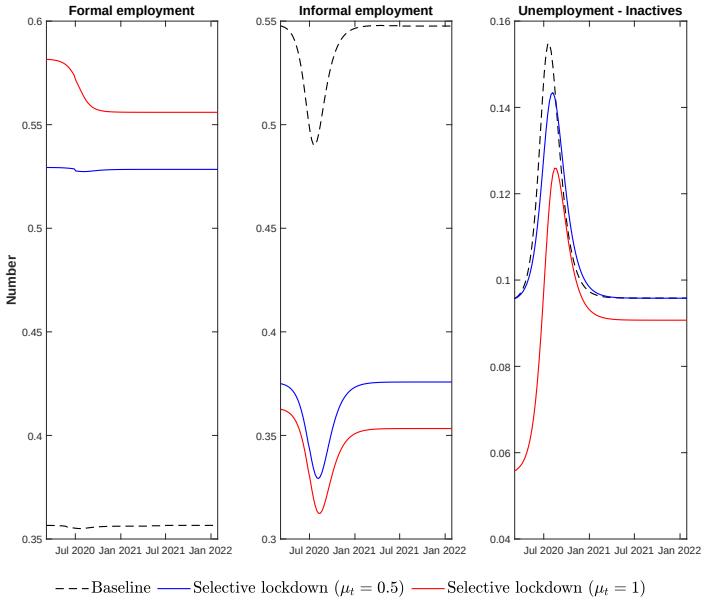


Figure 12: Employment - Selective lockdown.

Table 4 summarizes the results of the policy experiments for the simulated Colombian economy. Targeted transfers, both in generalized and selective lockdowns, generate shallower recessions. Selective lockdowns on

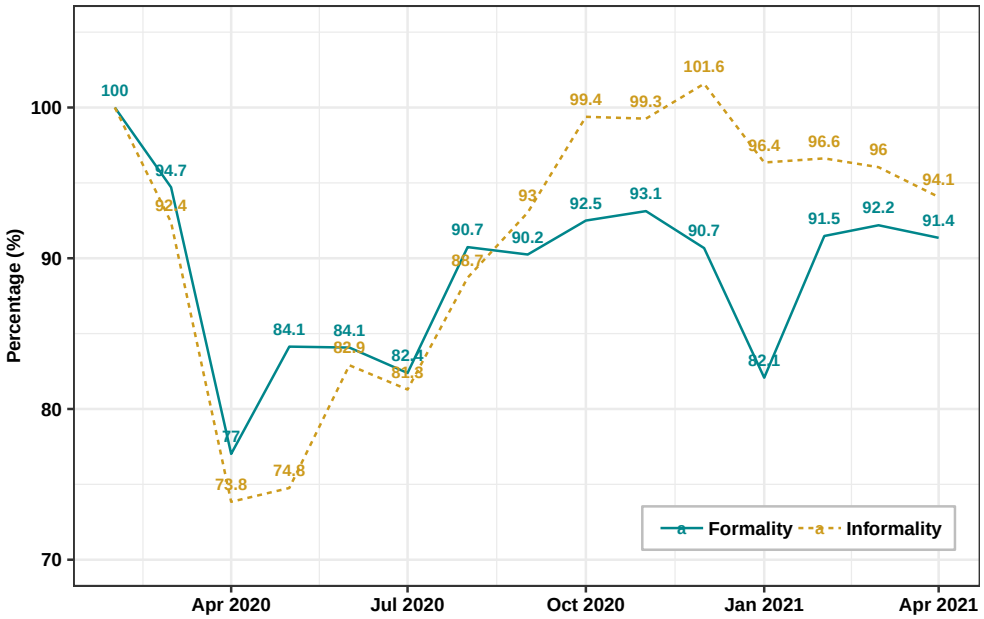
the informal sector are preferred to complete lockdowns because they generate a substitution towards the formal sector that eases the drop of aggregate consumption with best epidemiological results than generalized lockdowns. A combination of targeted transfers and generalized lockdowns, as in fact happened, lead to a greater dip in the economy, compared to the overall targeted counterpart. The model predicts most of the variables of interest fairly well. However, the drop in consumption observed in the data is much lower than the one predicted by the model. For simplicity, we do not include savings in our model and, for this reason, agents have less tools to smooth the consumption path.

Table 4: Policy experiments - Colombia.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-7.00%	34.37%	0.0759%
Baseline	-1.81%	15.48%	0.0906%
Lockdown, $\mu = 0.5$	-32.36%	15.88%	0.0918%
Lockdown, $\mu = 1$	-47.17%	16.21%	0.0927%
Selective lockdown, $\mu = 0.5$	-19.06%	14.34%	0.0877%
Selective lockdown, $\mu = 1$	-25.32%	12.59%	0.0875%
Lockdown ($\mu = 0.5$) and targeted lump sum transfers	-27.32%	33.32%	0.0877%
Selective lockdown ($\mu = 0.5$) and targeted lump sum transfers	-18.85%	33.18%	0.0854%

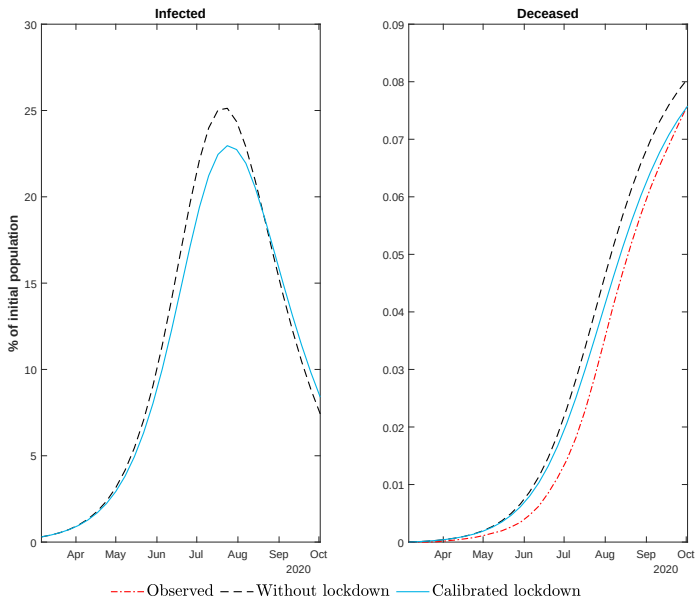
6.1.3 Calibrated lockdown

As we have pointed out before, the pandemic crisis has been different on how it affected informality. On this occasion the informal sector, at least at the beginning of the pandemic, was more affected than the formal sector due to the greater perception of contagion risk, as shown in figure 13. In the case of the Colombian economy, this was particularly evident in April and May 2020, where the number of informal workers as a proportion of the level observed in February 2020 fell to a low of 73.8%, while in the formal sector the fall reached 77%, having a minor impact. Subsequently, particularly after August 2020, when the Colombian government ended the strict lockdown, informal employment began to recover faster than formal employment. In fact, in the lockdown carried out at the beginning of 2021, formal employment is the most affected, while informality already reached the levels prior to the start of the pandemic. To explain this observed behavior, we propose an additional exercise in which we seek to replicate the observed creation of formal employment in the Colombian economy. Considering an exercise similar to the one presented in the previous section, here we calibrate different values for the lockdown in order to simulate the intensity of the lockdowns that were carried out in Colombia throughout 2020 and the first half of 2021. Table 5 summarizes the calibrated values for the consumption tax, which is how we simulate the consequences of the lockdown. As figure 14 shows, the model adequately replicates the epidemiological results of the first wave of infections experienced in Colombia until October 2020, particularly the number of deaths.



Note: the data observed are own calculations based on information from DANE.

Figure 13: Observed formal and informal employment.



Note: the data observed are own calculations based on information from DANE.

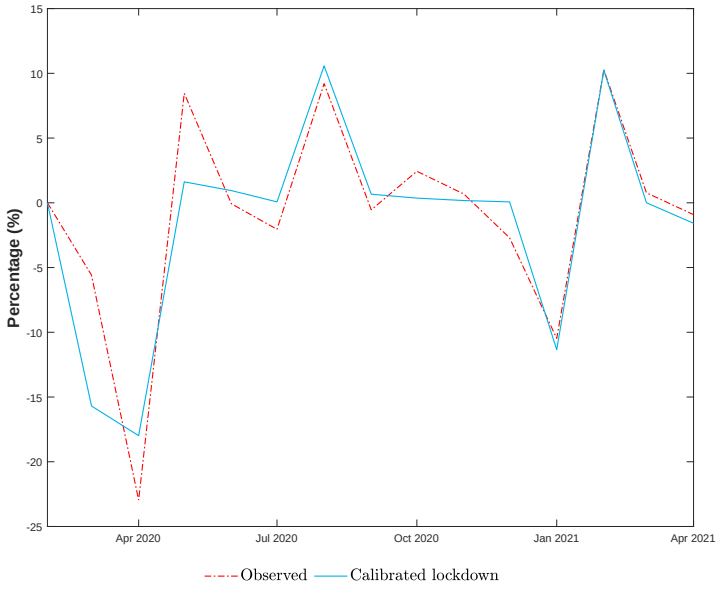
Figure 14: Epidemiological results - Calibrated lockdown.

Figures 15 and 16 shows the simulated and observed behavior of the relative formal and informal employment creation, respectively. As the results suggest, the model replicates the observed results of formal

Table 5: Lockdown values.

Month	μ
March - April	0.935
Last week of April	0.880
May - June	0.880
July	0.830
August - December	0.000
January	0.355
April - May	0.100

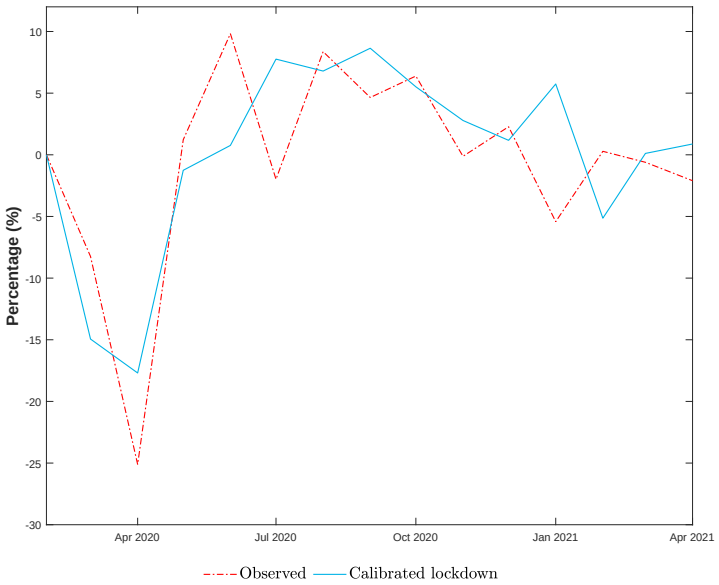
employment very well, particularly the falls observed in April 2020 and January 2021. In informality, the fall in informal employment observed in April 2020 is replicated relatively well, as well as the recovery dynamics observed since August 2020.



Note: the data observed are own calculations based on information from DANE.

Figure 15: Relative formal employment creation - Calibrated lockdown.

Table 6 summarizes the results of the calibrated model. We developed four exercises to simulate the behavior of the Colombian economy. The first exercise with targeted transfers, whose results were previously presented, adequately replicates the observed epidemiological and labor market results. The second exercise is similar to the first, but simulating an economy without hiring costs. As it can be seen, the results are



Note: the data observed are own calculations based on information from DANE.

Figure 16: Relative informal employment creation - Calibrated lockdown.

quantitatively similar, although the drop in consumption is of a slightly smaller magnitude.

Table 6: Calibrated lockdown results - Colombia.

Model	Annual fall Agg. Cons.	Max. Unemployment/Inactivity	Deceased
Observed	-7.00%	34.37%	0.0759%
Baseline	-1.81%	15.48%	0.0906%
Targeted lump sum transfers and calibrated lockdown	-15.03%	33.43%	0.0757%
Targeted lump sum transfers and calibrated lockdown without hiring costs	-13.81%	33.48%	0.0754%
Targeted lump sum transfers x 2 and calibrated lockdown	-11.52%	58.47%	0.0593%
Targeted lump sum transfers and calibrated selective lockdown	-11.94%	33.16%	0.0680%

Additionally, we simulate the effect of duplicating transfers in this calibrated model. Similar to the results described in section 6.1.1, this causes a considerable increase in the inactivity level. Finally, the fourth exercise simulates a scenario where the calibrated lockdown is selective and only focuses on the informal sector, with which a lower drop in consumption and better epidemiological results are observed, pointing out the importance of selective lockdowns, in epidemiological and economic terms.

6.2 Comparison with the Peruvian economy

The Peruvian economy has some distinct features compared to Colombia's. On one hand, the typical consumption bundle has a greater share of goods bought in informal markets, which makes households more prone to contract the virus. Second, it features a less distorted labor market since its minimum formal wage

and its associated payroll taxes are closer to the median informal wage than its Colombian counterpart. Finally, the transfers made to vulnerable households were relatively lower.

This combination leads to a greater recession in terms of consumption, despite having lower unemployment. The fall in consumption is greater because the size of the informal sector and its corresponding fall is larger. Table 7 also shows the effect of alternative settings. Again, the differential risk of contagion increases the size of the recession in 0.21 pp and having sticky prices generates a deeper fall of aggregate consumption of 0.04 percentage points. This drop is slightly greater than the one for Colombia because it prevents the substitution of informal consumption, which is substantially bigger.

Table 7: Baseline results - Peru.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-8.61%	43.77%	0.3740%
Baseline	-1.98%	11.65%	0.0936%
Without reduction in productivity of infected people	-0.36%	5.51%	0.0937%
Same probability of infection in both sectors	-1.77%	8.91%	0.0849%
Sticky prices	-2.02%	11.78%	0.0936%

Table 8 shows the results for the different policy experiments. The qualitative results are similar to those for Colombia. However, targeted transfers depress economic activity less because of their smaller size. Selective and general lockdowns have a similar effect for the Peruvian and the Colombian economies. The reason for this similarity, despite having a larger share of informal goods, is its less distorted labor market. Figure 17 shows a simulation for Colombia with the corresponding Peruvian payroll taxes and compares it with the baseline calibrations. It is clear that a lower distortion in the formal sector allows for a slightly faster recovery through an increase in the formality rate, though unemployment exhibits the same path.

Table 8: Policy experiments - Peru.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-8.61%	43.77%	0.3740%
Baseline	-1.98%	11.65%	0.0936%
Lockdown, $\mu = 0.5$	-31.41%	11.82%	0.0942%
Lockdown, $\mu = 1$	-46.23%	12.79%	0.0940%
Selective lockdown, $\mu = 0.5$	-23.35%	10.35%	0.0906%
Selective lockdown, $\mu = 1$	-24.75%	10.14%	0.0904%
Lockdown ($\mu = 0.5$) and targeted lump sum transfers	-25.39%	25.00%	0.0909%
Selective lockdown ($\mu = 0.5$) and targeted lump sum transfers	-18.83%	24.41%	0.0879%

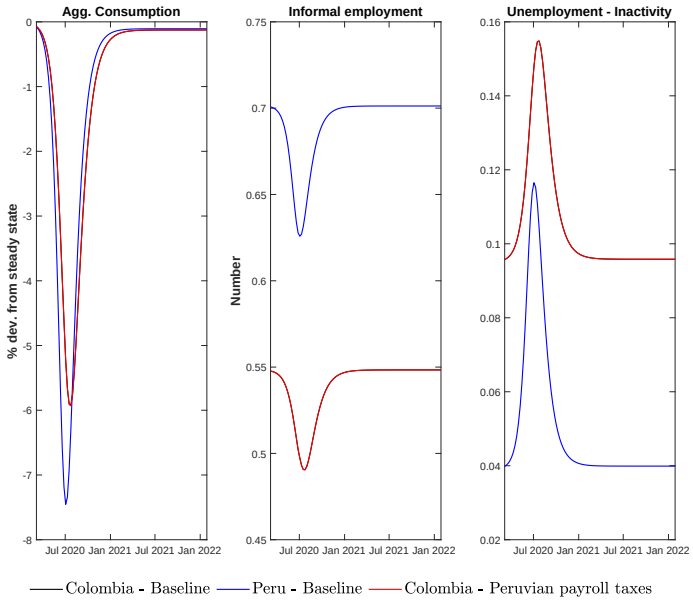


Figure 17: Consumption and employment.

7 Concluding Remarks

We provide a model to understand the role of informality in the recovery from the COVID crisis. We argue that a higher risk of contagion for the informal sector slows its ability to lead the recovery. The paper also highlights the role of flexible prices and less distorted labor markets to increase the speed of recovery.

We analyze the effects of four policy measures both in terms of contagion and in terms of economic activity: general and selective lockdowns, lump sum transfers, targeted transfers and reductions in payroll taxes. Lockdowns reduce economic activity and do not decrease the spread of the disease. Selective lockdowns on the informal sector are better than generalized lockdowns because they can achieve best epidemiological results but they also stimulate a substitution towards the formal sector that eases the drop of aggregate consumption.

Targeted transfers help to reduce the negative impact of the pandemic on the income of the vulnerable population and, in this way, facilitate self-care measures for this population. However, these transfers also reduce the labor supply and, with it, the level of economic activity. Universal transfers stimulate aggregate demand and, in particular, generate a boost in formal consumption. Therefore, universal transfers generate an increase in the price of the formal good and positively affects the formality rate. Nonetheless, there is also a negative effect on the supply of informal labor, similar to the one produced by targeted transfers, not to mention their higher cost.

Regarding the differences between Peru and Colombia, first, informal goods have a higher share in the consumption bundle of Peruvian families and, for this reason, households are more prone to contagion. Second, the Peruvian labor market is less distorted and its reaction to a shock is likely to be faster. Finally, the transfers made to vulnerable households were relatively lower in Peru. These differences help understanding why Peru experienced a greater recession, despite having lower unemployment.

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Appendix

This section considers the epidemiological and economic impact of targeted transfers. In our model, these transfers are focused on people who work in the informal sector because these people are the most vulnerable in economic terms and have a greater exposure to contagion by the virus, according to what was stated in the Introduction.

As figure 18 indicates, just like generalized transfers, higher targeted transfers generate a greater epidemiological impact, reducing the percentage of infected and deceased people. A greater transfer also eases the fall in formal consumption, although it deepens the fall in informal consumption. As a result, total consumption drops even more than in the baseline as shown in figure 19.

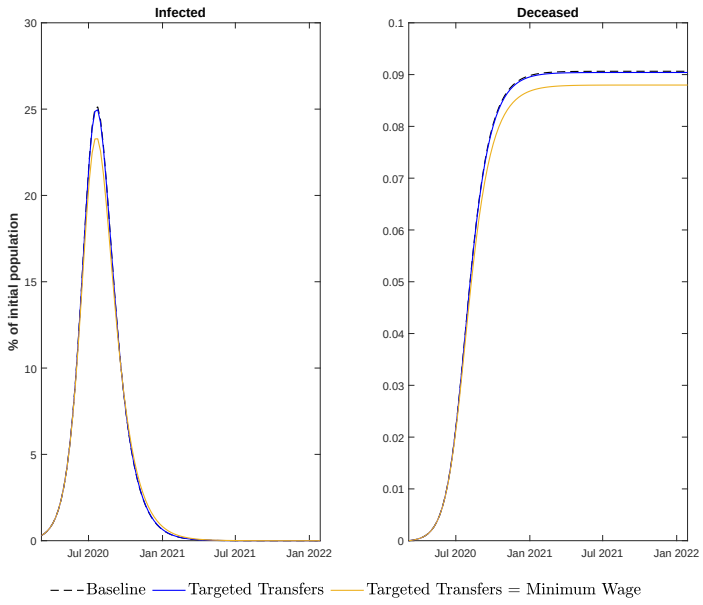

Figure 18: Epidemiological results - Targeted lump sum transfers.

This apparently contradictory result of a greater drop in the consumption of informal goods as targeted transfers are higher is the result of a reduction in the labor supply. As people who work in the informal sector receive larger transfers, they decide to work less due to the higher risk of contagion in this sector. As shown in figure 20, informality falls to 38%, while unemployment and inactivity rise to 26.8%. With this reduction in the supply of informal labor, the production and consumption of informal goods fall.

As shown in table 9, as targeted transfers increase in value, the drop in consumption decreases. However, this only happens until the calibrated transfers are multiplied by two. Once this threshold is exceeded, consumption begins to fall again in a greater proportion due to a reduction in the labor supply in the informal sector, causing a fall in the aggregate output of the economy.

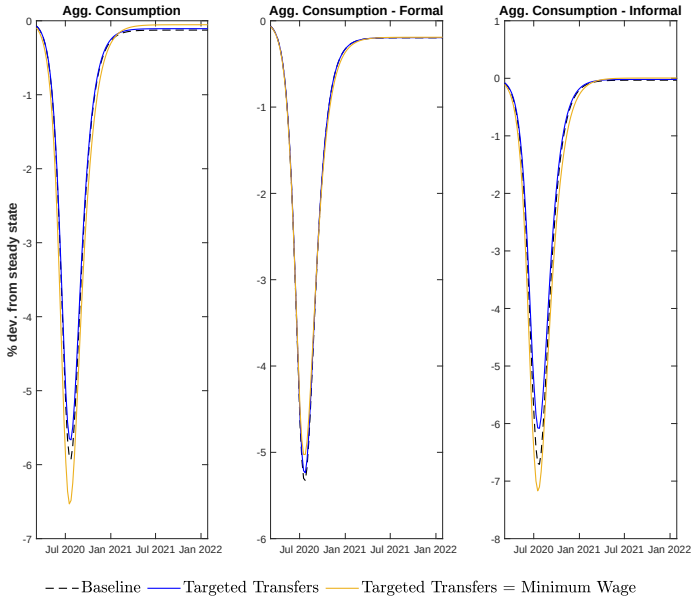

Figure 19: Consumption - Targeted lump sum transfers.

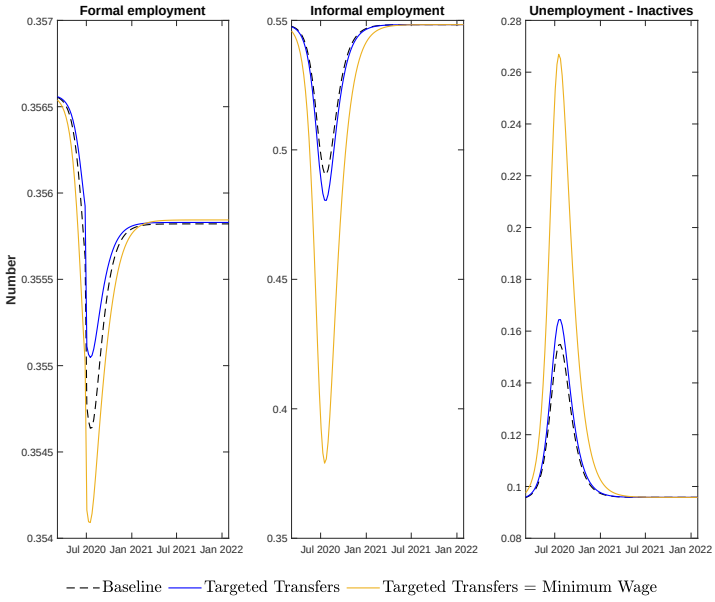

Figure 20: Employment - Targeted lump sum transfers.

Table 9: Targeted lump sum transfers results - Colombia.

Model	Annual fall Agg. Cons.	Max. Unemployment - Inactivity	Deceased
Observed	-7.00%	34.37%	0.0759%
Baseline	-1.81%	15.48%	0.0906%
Targeted lump sum transfers	-1.74%	16.44%	0.0904%
Targeted lump sum transfers x 2	-1.72%	17.71%	0.0901%
Targeted lump sum transfers x 3	-1.76%	19.31%	0.0897%
Targeted lump sum transfers x 4	-1.83%	21.26%	0.0892%
Targeted lump sum transfers x 5	-1.94%	23.58%	0.0887%
Targeted lump sum transfers: equivalent to minimum wage	-2.10%	26.69%	0.0879%