

Conceptual Paper

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Labor market effects of COVID-19 shocks

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Abstract: We study the impact of several Covid-19 related supply shocks. We use a standard wage setting-price setting model of the labor market and analyze the transmission of the shocks to the natural rate of unemployment and production. In a first step, the shocks are analyzed in a general way, graphically and algebraically. In a second step, numerical examples illustrate the effects on the real wage and the labor market equilibrium as well as output. Our theoretical results indicate that the negative supply shocks related to the Covid-19 pandemic are associated with a decline in the natural level of output and employment. Our results are supported by empirical evidence across various countries. However, limitations of the theoretical model can be considerable.

Keywords: labor market, natural rate of unemployment, supply shocks

JEL Classification: A22, E24, J20

The views expressed in this paper reflect those of the authors and not necessarily those of the institutions for which they work. Any remaining errors are the responsibility of the authors.

1 Introduction

From a macroeconomic perspective, the Covid-19 crisis represents a combination of a negative supply and a negative demand shock [Baqae and Farhi, 2020]. More specifically, the interruption of production activities led to a supply shock and lower consumer confidence and the decline in the investment climate led to a significant drop in global demand.

On the supply side, not only did the lockdowns and supply chain disruptions cause sudden production stoppages, but also the unexpected increase in production costs weighted heavily on the supply side, leading to adverse effects in the labor market [Dreger and Gros, 2021; Gros and Ounnas, 2021]. In particular, the enforcement of new regulations related to health measures, such as mandatory face masks and other hygiene measures, caused an increase of production costs [Bloom et al., 2020; Raimo et al., 2021]. In addition, numerous firms worldwide had to operate at reduced capacity to protect the health of customers and employees. This led to lower labor productivity, which in turn put pressure on prices [see Balleer et al., 2020].

In this paper, we analyze the effects of several Covid-19 related supply shocks on the labor market and the natural level of output. We apply a standard labor market model based on the determination of the wage setting and price setting relation [Blanchard, 2021]. Using a numerical example, we first derive a baseline scenario. Then, in order to determine the labor market effects of a Covid-19-induced supply shock, we modify one variable of the model to capture the shock and its effects in the labor market and the equilibrium output level. Finally, we provide some empirical evidence to cross check the theoretical results. To our knowledge, this is the first attempt to illustrate the Covid-19 related supply shock effects via the wage setting – price setting model.

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We structure our paper as follows: In Section 2, we derive the theoretical model and present the features of the baseline scenario numerically. In Section 3, we analyze the effects of isolated Covid-19 supply side shocks on the labor market. Here, we first derive the effects of an increase in the firms' mark-up. Then, we analyze the labor market effects of a decline in labor productivity, and finally, we consider the case of an increase in the reservation wage. In Section 4, we provide some empirical evidence, and in Section 5 we conclude.

2 Labor market equilibrium and the natural rate of output

2.1 Formal analysis

To analyze supply-side effects associated with the Covid-19 pandemic crisis, we apply the standard labor market model as represented by Blanchard [2021]. According to this model, the equilibrium in the labor market is determined by the wage and the price setting relationships. The wage setting relationship is given by

$$W = P^e \cdot F(u, z) \quad (1)$$

where wage (W) setting depends on

- the expected price level (P^e),
- the realized rate of unemployment (u), and
- a set of other factors (z).

The aggregate nominal wage depends positively on the expected price level, as an anticipated rise in the price level leads to higher wage claims of workers and their labor unions. Likewise, there is a negative relationship between the aggregate nominal wage (W) and the unemployment rate (u), which is in line with the traditional Phillips curve [Phillips, 1958]: A lower unemployment rate leads to better outside-options for workers and makes it more expensive for employers to find workers. This leads to a stronger bargaining position of workers and thus higher wages. The variable (z) captures all other factors (e.g., unemployment benefits and preferences for leisure) that affect the aggregate nominal wage, given the expected price level and the unemployment rate.

For simplicity and consistency with the traditional model, we assume static expectations, i.e., the expected price is equal to the current price ($P^e = P$). We also assume that the real wage (W/P) can be expressed by the following linear function: $F(u, z) = z - u$. Using this relationship in equation (1) together with static expectation leads to:

$$\frac{W}{P} = z - u \quad (2)$$

While wage setting depends on the bargaining position of workers, prices are set by firms and depend on their cost structure. The cost structure of a firm is in turn determined by the underlying production function. Assuming that labor is the only factor of production, we apply the following production function:

$$Y = A \cdot N \quad (3)$$

where Y is output, N is employment, and A is labor productivity.¹

¹ Alternatively, we can use a Cobb–Douglas production function of the form $Y = A \cdot N^{1-\alpha} \cdot K^\alpha$. Here, the marginal productivity of labor is given by $\partial Y / \partial N = A \cdot (1-\alpha) \cdot \frac{K^\alpha}{N^\alpha}$. In this case, the marginal productivity of labor is not constant, but decreases with a higher input of labor. While this makes the analysis somewhat more complex, it does not change the qualitative findings of our analysis.

The quantity of output produced depends on the number of workers employed and labor productivity. Total cost of producing Y is the product of the amount of labor required to produce Y , which - according to (3) - is Y/A , and the wage rate. Hence, total cost of producing Y is $(Y/A) \cdot W$. Marginal cost - i.e., the first derivative of the cost function with respect to output - is W/A .

We assume the following price setting relation:

$$P = (1 + \mu) \cdot \frac{W}{A} \Rightarrow \frac{W}{P} = \frac{A}{1 + \mu} \quad (4)$$

Prices are determined by marginal costs (W/A) and the mark-up (μ). Given the market power of firms, firms can raise prices over marginal costs. Therefore, the mark-up can be interpreted either as a profit margin or as compensation for price changes of other input factors such as material or energy.

Equating the wage setting relationship (2) and the price setting relationship (4) yields the equilibrium real wage and the corresponding natural rate of unemployment for the economy under consideration:

$$z - u = \frac{A}{1 + \mu} \Rightarrow u = z - \frac{A}{1 + \mu} \quad (5)$$

The natural rate of unemployment characterizes the equilibrium in the labor market in which the real wage chosen by wage setters is equal to the real wage implied by price setters. The equilibrium level of unemployment is not a natural constant, but rather reflects the structure of the economy designed by policy makers and the institutional framework. For instance, changes of the unemployment insurance schemes or the minimum wage would change the natural rate of unemployment. We later give more specific examples of how the market outcome and hence the natural rate of unemployment changes due to government intervention. For example, we discuss the effects of changes of the size of unemployment benefits or the time period for which unemployment benefits are granted. Additionally, the government also influences the mark-up by a tighter or softer competition policy, which affects μ and thereby the equilibrium rate of unemployment.

Figure 1 illustrates the wage setting relationship (WS) and the price setting relationships (PS). The price setting curve is a horizontal line. Since there exists a negative relationship between the unemployment rate and the real wage, the WS curve is downward sloping. In point A, the labor market is in equilibrium.

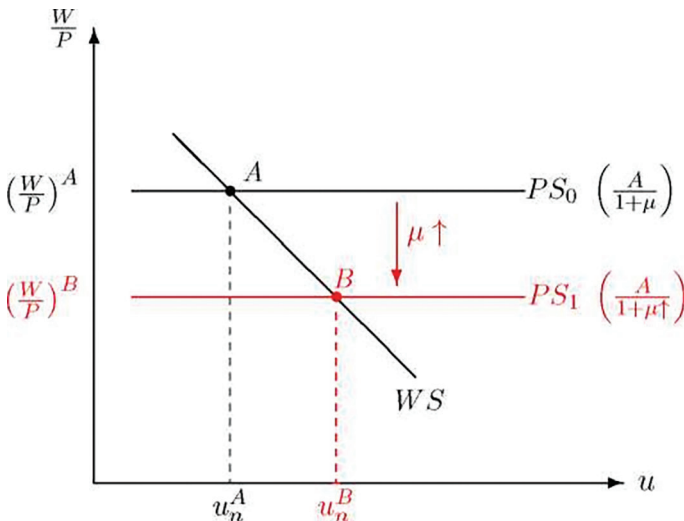


Figure 1. An increase in the mark-up.

2.2 Baseline scenario

We apply a numerical example to the WS–PS model in order to derive the effects of various supply shocks on the labor market. The values for the different exogenous variables and parameters as well as the size of the exogenous shocks were chosen arbitrarily to illustrate the main results in a simple way.

The baseline scenario is characterized by the following parameters:

- For z , we use a value of $z = 1.8$.
- The mark-up is $\mu = 0.25$.
- The labor productivity parameter is $A = 2$.
- The labor force of the respective economy is $L = 1,250$.

Using these assumptions, we can derive the equilibrium in the labor market, which is represented by the natural rate of unemployment.

$$u = z - \frac{A}{1 + \mu} = 1.8 - \frac{2}{1 + 0.25} = 0.2 \quad (6)$$

Thus, the natural rate of unemployment is given by $u = 0.2$ and the natural rate of employment is given by $1 - 0.2 = 0.8$. Substituting the values for labor force (L) and the natural rate of unemployment (u) into the following equation yields:

$$N = L \cdot (1 - u) = 1,250 \cdot (1 - 0.2) = 1,000 \quad (7)$$

Hence, the number of employees is given by $N = 1,000$. Given the production function, this information allows us to determine the natural level of output.

$$Y_n = A \cdot N_n = 2 \cdot 1,000 = 2,000 \quad (8)$$

The natural level of output is reached when the labor market is in equilibrium. Table 1 summarizes the numerical values for the baseline scenario.

Table 1. Baseline scenario and shocks

	Base	$\mu \uparrow$	$A \downarrow$	$z \uparrow$
z	1.8	1.8	1.8	1.9
μ	0.25	1/3	0.25	0.25
A	2	2	1.875	2
$A/(1 + \mu)$	1.60	1.50	1.50	1.60
W/P	1.60	1.50	1.50	1.60
$u_n = z - A/(1 + \mu)$	0.20	0.30	0.30	0.30
L	1,250	1,250	1,250	1,250
$N_n = L(1 - u_n)$	1,000	875	875	875
$Y_n = A \cdot N_n$	2,000	1,750	1,641	1,750

3 Application of COVID-19 related shocks

3.1 A mark-up shock

During the Covid-19 crisis, firms around the world faced new regulatory standards related to health measures. Studies show that government regulations during the pandemic led to adverse effects in the

labor market [Dreger and Gros, 2021; Raimo et al., 2021]. In particular, firms that provide services, e.g., hair salons, movie theaters, and restaurants had to introduce measures to protect customers and employees and were required by law to operate at reduced capacity. Rio-Chanona et al. [2020] show that especially low-wage occupations are more vulnerable to shocks during the pandemic. For example, in the case of a hair salon, the following measures were introduced:

- Mandatory wearing of face masks for hairdressers and customers.
- Mandatory cleaning of chairs and work materials after each customer.
- Serving customers by appointment only.
- Serving only a limited amount of customers at a time.

These measures were particularly cost-intensive. Prices, therefore, had to be adjusted virtually across the board. The price increase only covered additional costs and did not lead to higher profits.

To analyze the impact of higher costs faced by firms during the Covid-19 crisis on the labor market and the natural rate of output, we modify the baseline scenario such that higher production costs take the form of a higher mark-up on the costs until then. For this reason, we allow for a certain percentage increase in prices that is shown by a higher mark-up, which then affects the price setting relationship. We do not interpret the mark-up adjustment as an increase in profit margin. Rather, the higher mark-up is necessary to cover the additional costs such as masks, disinfection, etc. Applying this to equation (4) leads to

$$P = (1 + \mu \uparrow) \cdot \frac{W}{A} \Rightarrow \frac{W}{P} = \frac{A}{1 + \mu \uparrow} \quad (9)$$

In the labor market model, the increase in the mark-up is associated with higher costs and affects the PS relationship. For instance, at a given wage level firms will increase prices owing to the new health care regulations. This leads to a lower real wage. In Figure 1, the PS curve shifts downwards. Workers accept the lower real wage owing to an increasing unemployment rate (movement along the WS curve from point A to point B). Therefore, the natural rate of unemployment increases until the new labor market equilibrium is reached. Figure 1 shows the changes in the labor market when mark-up increases.

These results are confirmed by the numerical example. Table 1 displays the results of an increase in the mark-up. With additional production costs, we assume an increase of the mark-up from $\mu = 0.25$ to $\mu = 1/3$. Keeping labor productivity and the catch-all variable constant at $A = 2$ and $z = 1.8$, respectively, we can derive the labor market equilibrium for the mark-up shock scenario.

$$\frac{W}{P} = \frac{A}{1 + \mu \uparrow} = \frac{2}{1 + 0.333} = 1.5 \quad (10)$$

Applying the PS relation, the increase in the mark-up leads to a lower real wage of 1.5. Equating the PS relationship and the wage-setting relationship yields the effect on the natural rate of unemployment.

$$u = z - \frac{A}{1 + \mu \uparrow} = 1.8 - \frac{2}{1 + 0.333} = 0.3 \quad (11)$$

Consequently, unemployment rises to $u = 0.3$ and the natural level of employment declines to $N = 875$. This in turn results in a lower natural level of output equal to 1,750.

3.2 A labor productivity shock

The Covid-19 pandemic crisis had a negative impact on the supply side because of higher costs and because of lower labor productivity [Bloom et al., 2020]. For example, because restaurants were less busy during

the pandemic and hairdressers were only able to serve one customer at a time, labor productivity declined significantly.

To analyze the impact of lower labor productivity during the Covid-19 crisis on the labor market and the natural rate of output, we modify the baseline scenario to account for a decline in the labor productivity variable A . According to the labor market model used in this analysis, lower labor productivity affects the PS relation as follows:

$$P = (1 + \mu) \cdot \frac{W}{A \downarrow} \Rightarrow \frac{W}{P} = \frac{A \downarrow}{1 + \mu} \quad (12)$$

The decline in labor productivity is associated with higher prices, because firms can only produce less if all other factors remain constant. Hence, the price increase results in a lower real wage. In Figure 2 the PS curve shifts downwards. This leads to a lower real wage and a higher unemployment rate (movement along the WS curve from point A to point B).

These results are confirmed by our numerical example. Column 4 of Table 1 shows the results for this scenario. Given lower productivity, we assume a decline in the parameter A from $A = 2$ to $A = 1.875$.

Keeping the values for the mark-up and the variable z - which reflects all other labor market settings - constant at $\mu = 0.25$ and $z = 1.8$, respectively, we can derive the labor market equilibrium for the labor productivity shock scenario.

$$\frac{W}{P} = \frac{A \downarrow}{1 + \mu} = \frac{1.875}{1 + 0.25} = 1.5 \quad (13)$$

Using the PS relation, the decline in labor productivity leads to a lower real wage of 1.5 in the labor market. Equating the price setting and wage setting relation yields the effect on the natural rate of unemployment.

$$u = z - \frac{A \downarrow}{1 + \mu} = 1.8 - \frac{1.875}{1 + 0.25} = 0.3 \quad (14)$$

Hence, unemployment increases to $u = 0.3$ and the natural level of employment declines to $N = 875$. It can be shown that, depending on the magnitude of the decline in labor productivity, the same effects on the labor market can be derived as in case of the mark-up shock scenario.

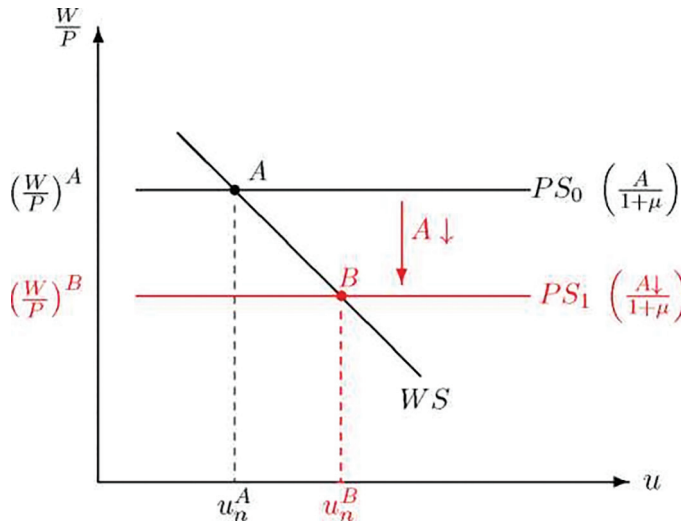


Figure 2. A decline in labor productivity.

However, the impact on the natural level of output is twofold. First, the negative impact on employment through the PS channel, as derived above, lowers output. Second, given the lower level of labor productivity, the natural rate of output per se will be lower.

$$Y_n = A \cdot N_n = 1.875 \cdot 875 \approx 1,641 \quad (15)$$

Hence, fewer workers are employed and their productivity is lower.

3.3 A reservation wage shock

The final shock we analyze is a change in the variable z . This variable reflects all factors that affect wages given the expected price level and the unemployment rate. According to our model, an increase in z implies an increase in the reservation wage. The reservation wage is defined as the lowest wage rate at which the workers would accept a job. Previous studies show that the reservation wage depends on factors such as personal characteristics, duration of unemployment, and unemployment benefits [Christensen, 2001; Brown and Taylor, 2013].

In the wake of the Covid-19 pandemic crisis, the reservation wage has trended upwards. This is due, in particular, to the increase in unemployment benefits during the pandemic in several countries, e.g., the United States. In addition, the risk perception of going to work increased, especially in those areas in which it is almost impossible to avoid personal contact. Previous studies show the macroeconomic impact of cutting back on work in order to reduce the risk of getting infected [Eichenbaum et al., 2020]. In this case, workers might prefer to stay at home and collect benefits rather than continue to work. Therefore, the risk premium to go to work increases, leading to a higher reservation wage. The same applies to mandatory vaccination in some sectors such as the health sector or schools. Beland et al. [2020] examine the short-term effects of the Covid-19 crisis on employment and wages and conclude a reduction in labor force participation and an increase in unemployment.

To analyze the impact of a higher reservation wage on the labor market and the natural rate of output, we modify the baseline scenario allowing for an increase of the parameter z . Figure 3 shows the changes in the labor market when the reservation wage rises.

A higher risk perception associated with a certain occupation or an increase of unemployment benefits results in higher wage demand by workers for a given rate of unemployment. This is reflected in Figure 3 in an upward shift of the WS curve. As firms are unwilling to pay a higher real wage, given the tight situation

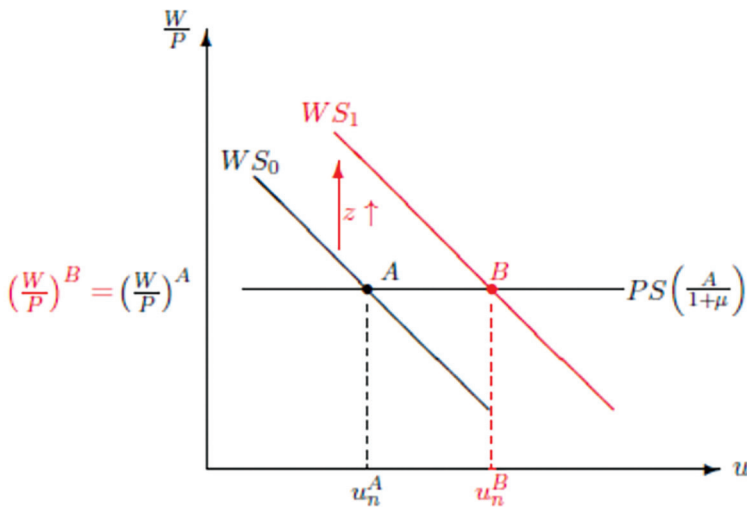


Figure 3. An increase in the reservation wage.

in the labor market, unemployment will rise, as reflected in Figure 3 in the movement along the PS curve from point *A* to point *B*. Therefore, the natural rate of unemployment will increase until a new labor market equilibrium is reached.

These results are supported by our numerical example. Column 5 of Table 1 shows the effects of an increase in the value taken by the variable z from $z = 1.8$ to $z = 1.9$. As Figure 3 shows, this shock leads to a higher level of unemployment.

$$u = z \uparrow - \frac{A}{1+\mu} = 1.9 - \frac{2}{1+0.25} = 0.3 \quad (16)$$

However, the real wage is unaffected:

$$\frac{W}{P} = z \uparrow - u = 1.9 - 0.3 = 1.6 \quad (17)$$

In equilibrium, the natural rate of unemployment rises to 0.3 and the real wage remains unaffected at its level of 1.6. However, the increase in the unemployment rate is associated with a decline in employment, and thus, a lower level of output.

$$Y_n = A \cdot N_n = 2 \cdot 875 = 1,750 \quad (18)$$

The effects of the reservation wage shock on the natural rate of unemployment and the natural rate of output are comparable to the effects of the mark-up shock.

4 Does the model fit the data?

Based on the WS–PS model, our theoretical results indicate that the Covid-19 related supply shocks lead to a deterioration in the labor market, a higher unemployment rate, and a lower level of output. To underpin these theoretical findings with empirical evidence, we use quarterly data for labor productivity, the unemployment rate, the labor force, and GDP for four countries (Germany, Poland, the UK, and the U.S.) and the OECD total. The data are taken from the OECD database and span from Q1 2018 to Q4 2021. We proceed in two steps. We split our data set into a pre-pandemic period, covering the period Q1 2018–Q4 2019, and a pandemic period, covering the period Q1 2020–Q4 2021. Second, we calculate the average values of the respective variables for the pre-pandemic period and the pandemic period in order to eliminate possible fluctuations, which might have been caused by, for example, lockdowns during the pandemic. This strategy allows us to compare the economic developments right before the outbreak of the Covid-19 crisis with the developments during the pandemic. Table 2 shows the resulting values.

To observe the developments in labor productivity, we use an index for the unit labor costs as a proxy. A higher value of the index is associated with lower labor productivity. The data show that for all countries under consideration as well as the OECD total, the index value for the pandemic period is clearly above the pre-pandemic value, indicating lower labor productivity. This finding is in line with our theoretical results and supports previous empirical outcomes. For example, Bloom et al. (2020) show that total factor productivity declined by 5 percent over the period 2020 to 2021, whereas hourly labor productivity declined by 2.3 percent on average, using monthly firm survey data for the UK.

With respect to the unemployment rate, we observe a drastic increase during the pandemic for most countries under consideration. Especially in the U.S. the increase in the unemployment rate from 3.7 during the pre-pandemic period to 6.7 during the pandemic is noteworthy. In Poland, however, the unemployment rate declined on average over the considered pandemic period. This outcome might reflect the adjustment flexibility of the Polish economy to changing economic conditions. A study by Bieszk-Stolorz and Markowicz [2022] shows a higher degree of willingness among Polish unemployed to take up a job since the outbreak of the Covid-19 pandemic.

Table 2. Empirical evidence

		Germany	Poland	UK	US	OECD total
Unit labor	Pre-pandemic	107.5	109.2	108.4	106.4	106.6
Costs ¹	Pandemic	113.8	119.7	122.3	114.5	114.0
Unemployment	Pre-pandemic	3.1	3.6	4.0	3.8	5.5
rate	Pandemic	3.6	3.3	4.5	6.7	6.7
Labor force ¹	Pre-pandemic	61.6	56.3	63.9	63.0	60.8
	Pandemic	61.1	56.7	63.4	61.7	59.6
GDP ^{1,2}	Pre-pandemic	106.7	116.6	106.3	108.2	108.0
	Pandemic	104.3	120.2	98.9	109.6	107.0

¹Index value, 2015 = 100.

²Seasonally adjusted volume values: pre-pandemic (Q1 2018–Q4 2019) and pandemic (Q1 2020–Q4 2021).

Source: OECD database.

Interestingly, we also observe a decline in the labor force participation rate during the Covid-19 pandemic. For the country sample under consideration, the US represents the economy with the largest decline. In contrast to our theoretical model, where we only assume an increase in the reservation wage, the pandemic might have led to a withdrawal of individuals from the labor market. Hence, we observe a drop in the labor force participation rate. Again Poland seems to represent an exception here.

To examine the output developments, we use the GDP volume index, which captures the production activities of a country. A lower value indicates a decline in output. While we observe a decline in most countries under consideration for the pandemic period, which is in line with our theoretical results, we observe an increase for Poland and the US. Especially for Poland, the increase by about 3 percent to 120.2 from 116.6 is striking. These data likely reflect the flexibility of the Polish economy to adjust quickly to economic shocks. This result is supported by a study of the OECD showing only mild Covid-19 effects on the Polish economy. However, the results show a high degree of dispersion, when it comes to different economic cohorts and regions in Poland (OECD, 2021).

The data examined here can be interpreted as a general support for our theoretical model, which is applicable in the illustration of the basic labor market effects associated with the Covid-19 crisis. However, simplifications of the theoretical model lead to some limitations of our findings. First, the model represents a static model not allowing for any dynamic developments and spillovers. This does not hold for real economic developments, as can be seen by changes in the labor force participation rate. Second, in our theoretical model, we treat the labor market variable z as an exogenous shock. However, some policy makers like the US government reacted to the high unemployment rate by implementing countermeasures. Therefore, z is likely to be a function of the unemployment rate $z(u)$. Third, our theoretical model does not take into account the flexibility of the labor markets in reacting to an economic shock. As can be seen in the case of Poland, this aspect is, however, important as it can not only lower the magnitude of the associated negative effect but even revert it, as economic agents are going to adjust to new economic conditions.

5 Conclusion

From a macroeconomic perspective, the Covid-19 pandemic crisis represents a combination of a negative demand shock and a negative supply shock. Using a standard model of the labor market, this paper analyzes the transmission of several Covid-19 related supply shocks to the labor market. More specifically, we apply the WS–PS model, as represented by Blanchard [2021], to determine the effects of the shocks on the labor market equilibrium and the natural rate of output.

This paper examines the effects of the supply shocks in two ways. First, the effects of the shocks are derived theoretically. Second, the effects are shown using stylized numerical examples to examine the theoretical results. To this end, we define a baseline scenario and present alternative shock scenarios. All shocks are analyzed under the ceteris paribus condition.

Our results show that negative supply shocks caused by the Covid-19 pandemic have a deteriorating impact on the natural level of output and lead to a higher unemployment rate. Lower labor productivity, the increase of the reservation wage, and the enforcement of new regulatory standards related to Covid-19 health measures lead to a higher natural rate of unemployment and a lower level of output. While the results of all three shocks are comparable in terms of labor market outcomes, the decline in labor productivity seems to have the largest impact on output. This is due to two reasons. First, the decline in labor productivity leads to a decline in employment via the price setting relation, and thus, to a decline in output. Second, the lower number of workers in combination with lower labor productivity leads to an even lower level of output.

In order to provide empirical evidence, we investigate the developments of GDP, labor productivity, the unemployment rate, and the labor force for several countries during the pre-pandemic period and the period of the pandemic. Overall the data support the findings of the theoretical model. However, in some cases, the data do not entirely fit the model, which might reflect crucial limitations of the static theoretical framework. Hence, further and in-depth theoretical and empirical analyses are needed to derive more comprehensive results.

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