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# The impact of wage rigidity on inflation within the framework of the transmission mechanism of monetary policy

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## Abstract

This work investigates the significance of wage rigidity in the context of formulating monetary policy in Kazakhstan. The assessment of the impact of wage rigidity on inflation was conducted within the framework of a New Keynesian model, in which the labor market is characterized by search and matching frictions, as described in the work of Christoffel et al. (2008) [2].

The results showed that a labor market characterized by lower wage rigidity significantly alters the transmission of shocks. For example, inflation responds more quickly to a monetary policy shock and becomes less stable with more flexible wages.



*Keywords: wage rigidity, inflation, labor market.*

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# CONTENT

## 1. INTRODUCTION

A key aspect of the activities of many central banks is ensuring price stability, which is achieved through the control of inflation levels. In this regard, it is important to understand the factors influencing inflation dynamics. The relationship between wages and inflation plays a significant role in explaining changes in aggregate prices. All else being equal, wage increases are associated with higher inflation rates, and slow wage adjustment to shocks leads to inflation inertia, i.e., inflation stability. Nominal and real frictions, which determine the nature of price adjustments in the economy, play an important role in this chain.

Rigidity and frictions in the labor market can affect inflation dynamics in various ways and, therefore, become important in the formulation of monetary policy. There are beliefs that sluggish inflation responses to shocks may be due to the sluggish response of the labor market to shocks[3]. This is explained by the fact that due to frictions in the labor market, caused by the difficulties and duration of finding a suitable worker-firm match, wages do not immediately respond to shock changes in the economy.

From the perspective of the New Keynesian concept, slow wage growth directly affects firms' marginal costs and their pricing, and therefore ultimately affects inflation dynamics, especially its stability. Labor market rigidity can also affect fluctuations in hours worked, influencing inflation dynamics through its impact on firms' marginal costs resulting from changes in the marginal product of labor. The institutional features of the model in this article can impact inflation through one or a combination of these channels.

This paper examines the significance of wage rigidity[4] for monetary policy in Kazakhstan. When analyzing the role of the labor market in establishing market prices, we rely on the methodology of Christoffel et al. (2008). The model simultaneously accounts for fluctuations in key labor market variables and the impact of wages on inflation. In this article, we construct a calibrated dynamic stochastic general equilibrium model that incorporates several characteristics: it includes the link between wages and inflation, replicates unemployment fluctuations over the business cycle, and implies a reasonable response of the unemployment rate to changes in unemployment benefits. The results show that a labor market characterized by lower wage rigidity significantly alters the transmission of shocks in our model of the Kazakh economy. For example, inflation responds more quickly to a monetary policy shock and becomes less stable with more flexible wages.

The importance of wage rigidity in macroeconomic models is highlighted by the research of Christiano et al. (2005), Edge et al. (2003), and Gali et al. (2001). These works highlight that one of the reasons for inertia in the economy is the speed of wage response to various changes. Recent studies, such as Gertler et al. (2020), also

[3] More details can be found in the studies by Walsh (2005), Trigari (2009), Christoffel et al. (2008), Christoffel et al. (2009).

[4] Wage rigidity refers to wages that do not adjust in response to changes in the prices of final goods and services. According to theory, wage dynamics lag behind the prices of final goods. Moreover, wage reductions occur much more slowly than wage increases.

emphasize the importance of wage rigidity for macroeconomic fluctuations. Christoffel et al. (2008) suggest that wage rigidity is more important for the impact of monetary policy on inflation than other labor market rigidities. This conclusion is closely related to the results of the study by Komatsu (2023), which indicates the more significant role of the wage channel in the transmission of monetary policy compared to the labor market channel. The work by Tolepbergen (2021), dedicated to the structure of the labor market, confirms that a flexible wage-setting process improves the transmission mechanism. Moreover, shocks affecting workers' bargaining power explain most of the fluctuations in output and inflation.

The rest of the article is structured as follows. Section 2 presents a New Keynesian model with search and matching frictions in the labor market and staggered wage negotiations. Section 3 presents the model calibration parameters for Kazakhstan. Section 4 describes the wage channel, and then Section 5 demonstrates the results of the obtained impulse responses. The main conclusions of the article are presented in Section 6.

## 2. MODEL

The mechanisms through which monetary policy affects inflation and real economic activity are central to macroeconomics. Over the past few decades, New Keynesian models have defined the prevailing view on this issue. This work constructs a New Keynesian business cycle model that incorporates labor market rigidity as described by Christoffel et al. (2008). We include "search and matching frictions" as outlined by Mortensen and Pissarides (1994) in the standard New Keynesian business cycle model. One time period in the model corresponds to a calendar quarter.

### 2.1. CONSUMER PREFERENCES AND CONSTRAINTS

Consumers have time-dependent preferences regarding expected utility. Consumer i's preferences can be represented as:

$$E_0\left\{\sum_{t=0}^{\infty}\beta^t u(c_{i,t}, c_{t-1}, h_{i,t})\right\},$$

where $E_0$ denotes expectations based on information available at time 0, and $\beta \in (0,1)$ is the time discount factor. $u(c_{i,t}, c_{t-1}, h_{i,t})$ is the standard utility function in the form:

$$u(c_{i,t}, c_{t-1}, h_{i,t}) = \frac{(c_{i,t} - \varrho c_{t-1})^{1-\sigma}}{1-\sigma} - k^L \frac{(h_{i,t})^{1+\varphi}}{1+\varphi}, \sigma > 0, \varphi > 0.$$

Here, $c_{i,t}$ denotes the consumption of consumer i, $c_{t-1}$ represents aggregate consumption in the previous period, and $h_{i,t}$ - refers to the number of hours worked by consumer i. $k^L$ - is a positive scaling parameter of labor disutility[5], while $\varrho \in [0, 1)$

[5] The parameter of disutility of work refers to the negative aspect or costs associated with performing work or labor. For example, in the model, individuals make decisions about how much to work based on the trade-off between the benefits of additional income and the cost of time spent working. The positive scaling coefficient helps quantify how willing people are to incur the costs of work in exchange for benefits.

indicates the external habit formation.[6] $\sigma, \varphi > 0$ represent relative risk aversion[7] and labor supply elasticity, respectively.

## FAMILY WELFARE AND BUDGET CONSTRAINTS

In the economy, there are a large number of identical families with a unit mass (the sum equals one). Each family consists of $1 - u_t$ employed members and $u_t$ unemployed members, both with the aforementioned preferences. The family maximizes the sum of the unweighted expected utilities of its individual members,

$$\int_0^1 E_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(c_{i,t}, c_{t-1}, h_{i,t}) \right\} di.$$

Let $U(c_{i,t}, c_{t-1}, u_t, \{h_{i,t}\})$ represent the aggregated utility function of the family for each period:

$$U(c_{i,t}, c_{t-1}, u_t, \{h_{i,t}\}) \coloneqq \int_0^1 u\big(c_{i,t}, c_{t-1}, h_{i,t}\big) di,$$

where $c_t$ is the average level of consumption of family members, and $\{h_{i,t}\}$ is a conditional representation of hours worked. The utility function U provides the value of periodic family utility when consumer expenditures are optimally allocated among family members. The representative family combines the labor income of its employed members, unemployment benefits of its unemployed members, and financial income. Its budget constraint is as follows:

$$c_t + t_t = \int_0^{1-u_t} w_{i,t} h_{i,t} di + u_t b + \frac{D_{t-1}}{P_t} R_{t-1} \epsilon_{t-1}^b - \frac{D_t}{P_t} + \Psi_t,$$

where $c_t$ s per capita consumption, which is the family's choice variable. $t_t$ represents lump-sum taxes per capita paid by the family. $w_{i,t} h_{i,t}$ is the real wage per hour multiplied by the number of hours worked by individual family member i. $b$ refers to the real unemployment benefits paid to unemployed $(u_t)$ family members. The family owns $D_t$ units of risk-free nominal bonds for one period, which pay a gross nominal return$R_t \epsilon_t^b$ in period t + 1. $P_t$ denotes the aggregate price level. $\epsilon_t^b$ represents a serially correlated shock to the risk premium, which follows an AR(1) process:

$$\log\big(\epsilon_t^b\big) = \rho_b \log\big(\epsilon_{t-1}^b\big) + \zeta_t^b, \text{ где } \rho_b \in [0,1) \text{ и } \zeta_t^b \sim N(0, \sigma_b^2).$$

This shock represents the premium between the returns on the assets of the representative household and the interest rate set by the central bank (see Smets and Wouters, 2007). The family owns shares in all firms within the economy. $\Psi_t$ denotes the real income in the form of dividends per family member, derived from the profits of these firms.

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[6] With external habit formation, the accumulated average level of past consumption in the economy as a whole influences the current utility of an individual consumer. The formation of external habits is a form of external effects in intertemporal consumption, whereby the consumer internalizes these external habits when making optimal decisions.

[7] Relative risk aversion, in the context of the utility function, is a measure that determines how much an individual is inclined to avoid risk when making consumption or investment decisions. This concept allows for modeling individuals' choices in situations where they face a trade-off between different levels of risk and potential returns.

The dividend income is divided into profits from wholesale trade ($\Psi_t^C$) and from labor-produced goods ($\Psi_{i,t}^L$), respectively:

$$\Psi_t = \Psi_t^C + \int_0^{1-u_t} \Psi_{i,t}^L di.$$

The family maximizes its welfare function by choosing consumption and bond holdings, taking budget constraints into account. The Euler equation in this case is given by:

$$1 = E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t \epsilon_t^b}{\Pi_{t+1}} \right\},$$

where the marginal utility of consumption is defined as $\lambda_t = (c_t - \varrho c_{t-1})^{-\sigma}$, $\beta$ is the discount factor, $R_t$ is the nominal interest rate, $\Pi_{t+1}$ represents inflation in the next period, and $\epsilon_t^b$ is the risk premium shock.

## 2.2. FIRMS

The model utilizes three production sectors. Firms in the first sector produce a homogeneous intermediate good, which we will call "labor goods." Firms producing labor goods hire exactly one worker for production. The hours worked in such firms are the sole factor of production. In the model, finding a worker is a labor-intensive and costly process due to market frictions. When a firm and a worker meet, Nash bargaining over the hourly wage is rarely used. The model follows the right-to-manage concept as in Trigari (2006) [8]. Given the wage level, the firm decides each period how many hours of work it wants to hire. According to the model's concept, firms and workers cannot negotiate their nominal hourly wage rate each period.

Subsequently, firms producing labor goods sell their product to the wholesale sector under perfect competition, as labor goods are homogeneous. Wholesale firms produce differentiated goods using labor goods as the sole production resource. The differentiated goods are then sold to the retail sector under monopolistic competition. Finally, retail firms combine the differentiated goods into a final good, which is sold to households and the government. We will now consider each sector individually. The subscript $j$ will refer to the wholesale firm/product $j$. The subscript $i$ will refer to the firm producing labor goods.

## RETAIL FIRMS

The retail sector operates in a perfectly competitive market. Here, wholesale goods of type $j \in [0,1]$, denoted as $y_{j,t}$, are used and all these varieties are combined into a homogeneous final good $y_t$, according to the equation:

$$y_t = \left( \int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \epsilon > 1$$

[8] The "right-to-manage" concept means that firms and workers only negotiate the hourly wage rate. Then, at this wage rate, the firm is free to choose the number of employees to hire according to the intensity (hours worked). As a result, the marginal wage rate and the average wage rate coincide.

where $\epsilon > 1$ is the elasticity of substitution between different varieties of wholesale goods.

The price of the final good (cost minimizing), $P_t$, required to produce one unit of the final good, is determined by the formula:

$$P_t = \left(\int_0^1 P_{j,t}^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}},$$

where $P_{j,t}$ is the price of the wholesale good $y_{j,t}$. The demand function for each good $y_{j,t}$ is presented as:

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} y_t.$$

## WHOLESALE FIRMS

Firms in the wholesale sector are denoted by the index $j$ and have a total mass equal to one ($j \in [0,1]$). Firm j produces the variety j of the differentiated good, $y_{j,t}$, according to the equation:

$$y_{j,t} = y_{j,t}^{L,d},$$

where$y_{j,t}^{L,d}$ denotes the demand of firm j for labor goods. Intermediate labor goods are purchased in a perfectly competitive market at the real price $x_t^L$. The real profit of firm j, $\Psi_{j,t}^C$, is determined by the formula:

$$\Psi_{j,t}^C = \frac{P_{j,t}}{P_t} y_{j,t} - y_{j,t}^{L,d} x_t^L,$$

where $P_{j,t}$ is the price of the wholesale good $y_{j,t}$, $P_t$ is the price of the final good, $y_{j,t}^{L,d}$ denotes the demand of firm j for labor goods, and $x_t^L$ is the real price of labor goods.

The first part of the equation describes the revenues of the wholesale firm, and the second part denotes the real payments for labor goods.

According to Calvo (1983) and Yun (1996), it is assumed that in each period a random fraction $\omega \in [0,1]$ of firms cannot re-optimize their prices. Those firms (1 - ω) that do re-optimize their price in period t face the problem of maximizing the value of their enterprise by choosing the sale price $P_{j,t}$, taking into account price stickiness, the demand function for differentiated goods, and the production function, given by the formula:

$$max\ (P_{j,t}) \qquad E_t\left\{\sum_0^\infty w^s \beta_{t,t+s}\left[\frac{P_{j,t}}{P_{t+s}} - mc_{t+s}\right] y_{j,t+s}\right\},$$

where s is the number of periods, $mc_t$ are the real marginal costs, which are defined as $mc_t = x_t^L$. $\beta_{t,t+s} := \frac{\beta^s \lambda_{t+s}}{\lambda_t}$ is the equilibrium stochastic discount factor. The typical first-order condition for setting the price of an optimizing wholesale firm is:

$$E_t\left\{\sum_0^\infty w^s \beta_{t,t+s}\left[\frac{P_t^*}{P_{t+s}} - \frac{\epsilon}{\epsilon - 1} mc_{t+s}\right] y_{j,t+s}\right\} = 0,$$

where $P_t^*$ denotes the optimal price. The aggregate real profit of the wholesale sector (Calvo) is given by $\Psi_t^C = \int_0^1 \Psi_{j,t}^C dj$ , where the profit of firm j for the period is given by:

$$\Psi_{j,t}^C = \left\{\frac{P_{j,t}}{P_t} - mc_t\right\} y_{j,t}.$$

The aggregate real profit is allocated to the representative household.

**FIRMS PRODUCING LABOR GOODS**

Labor goods are homogeneous. Each firm in this sector consists of one worker suited to the employer. Thus, in period $t$, there are labor firms with a mass of $(1 - u_t)$. The production function in this sector is represented as::

$$y_{i,t}^L = z_t h_{i,t}^\alpha,$$

where $y_{i,t}^L$ is the labor good produced at match $i$, и $\alpha \in (0,1)$ is the elasticity of production with respect to labor, and $h_{i,t}$ is the number of hours. $z_t$ represents a sector-wide technological shock that follows an AR(1) process:

$$\log(z_t) - \log(z) = \rho_z(\log\big(z_{t-1)} - \log(z)\big) + \zeta_t^z,$$

где $\rho_z \in [0,1)$ и $\zeta_t^z \sim N(0, \sigma_z^2), iid.$

## 2.3. LABOR MARKET

This section describes the key equations and relationships in the labor market. We will first discuss the matching technology, followed by the negotiation process and decision-making regarding job placements.

**MATCHING OF FIRMS AND WORKERS**

The process of matching firms and workers is governed by a Cobb-Douglas matching technology:

$$m_t = \sigma_m (u_t)^\xi (v_t)^{1-\xi}, \qquad \sigma_m > 0, \qquad \xi \in (0,1).$$

Where $m_t$ is the number of new matches between workers and firms, $v_t$ is the number of vacancies, $u_t$ is the number of unemployed, $\xi \in (0, 1)$ denotes the elasticity of matches with respect to unemployment, and $\sigma_m > 0$ is the matching efficiency parameter. A searching firm finds a worker in period t with a probability $q_t = \frac{m_t}{v_t}$. An unemployed worker finds a job with a probability $s_t = \frac{m_t}{u_t}$.

It is assumed that separations occur with a constant exogenous probability $\vartheta \in (0,1)$ in each period. New matches between firms and employees in period t influence employment in the following period t+1. As a result, the level of employment $n_t \coloneqq 1 - u_t$ changes according to the process:

$$n_t = (1 - \vartheta) n_{t-1} + m_{t-1}\,.$$

**WAGE BARGAINING**

The posting of vacancies is costly for firms, and the diminishing returns to scale create an economic rent from the matches formed between firms and employees.[9]

The model assumes that the household decides on the provision of labor for its workers. Therefore, the value (benefit) for the household of member $i$, employed with a nominal wage $W_{i,t}$, is equal to:

$$V_t^E(W_{i,t}) = \frac{W_{i,t}}{P_i} h_{i,t} - k^L \frac{h_{i,t}^{1+\varphi}}{(1+\varphi)\lambda_t} + E_t\{\beta_{t,t+1}(1-\vartheta)[\gamma V_{t+1}^E(W_{i,t}) + (1-\gamma)V_{t+1}^E(W_{t+1}^*)]\} + E_t\{\beta_{t,t+1}\vartheta U_{t+1}\},$$

where $V_t^E(W_{i,t})$ is the value of the employed household member, $W_{i,t}$ is the wage, $P_i$ is the price of the good, $h_{i,t}$ is the number of hours worked, $k^L$ is the positive scaling parameter of labor disutility, $\varphi > 0$ is the elasticity of labor supply, $\lambda_t$ is the marginal utility of consumption, $\beta_{t,t+1}$ is the discount factor, $\vartheta$ is the probability of dismissal, $\gamma$ is wage rigidity (the probability that the wage cannot be revised), and $U_{t+1}$ is the value of being unemployed in period *t+1*.

The above equation states that the value of the employed member $i$ depends on their real wage, the number of hours worked, and the disutility of their labor.

An employed worker retains their job with a probability of $1-\vartheta$. In the next period, if they remain employed, they face a probability of $\gamma$, that they will not be able to renegotiate their nominal wage. In this case, their value is $V_{t+1}^E(W_{i,t})$. Alternatively, they may renegotiate, and in this case, the value reflects the optimal wage discussed in the negotiation at *t + 1*: $V_{t+1}^E(W_{t+1}^*)$. With a probability of $\vartheta$, they will be unemployed in the next period. The value of the worker when unemployed is determined by:

$$U_t = b + E_t\{\beta_{t,t+1} s_t[\gamma V_{t+1}^E(W_t) + (1-\gamma)V_{t+1}^E(W_{t+1}^*)]\} + E_t\{\beta_{t,t+1}(1-s_t)U_{t+1}\},$$

where b represents unemployment benefits, $\beta_{t,t+1}$ is the discount factor, $s_t$ is the probability of finding a new job, $V_t^E(W_{i,t})$ is the expected value of the employed household member, and $\gamma$ denotes wage rigidity (the probability of not being able to renegotiate the wage).

The value of the unemployed individual depends on real unemployment benefits b. The unemployed participant faces a probability $s_t$ of finding a new job. In this case, they become productive in the next period and encounter the same wage-setting process, akin to Calvo, as the currently employed participant. With a probability of $(1-\gamma)$, they can negotiate a wage in *t + 1;* with a probability of γ, they will start working at the average nominal hourly wage under existing contracts in t, $W_t$. The last term in the equation reflects the value for the household if the currently unemployed family member remains unemployed in the next period. Let $\Delta_t(W_{i,t}) \coloneqq V_t^E(W_{i,t}) - U_t$ denote the difference in benefits to the family between having an employed versus an unemployed member:

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[9] In this context, "matching of firms and employees" means that employees meet the conditions set by firms and vice versa.

$$\Delta_{\mathrm{t}}(W_{i,t}) = \frac{W_{i,t}}{P_i} h_{i,t} - b - k^L \frac{h_{i,t}^{1+\varphi}}{(1+\varphi)\lambda_t}$$
$$+ E_t\{\beta_{t,t+1}(1-\vartheta)[\gamma V_{t+1}^E(W_{i,t}) + V_{t+1}^E(W_t^*{}_{t+1})]\}$$
$$+ E_t\{\beta_{t,t+1} s_t[\gamma V_{t+1}^E(W_t) + V_{t+1}^E(W_{t+1}^*)]\}$$
$$+ E_t\{\beta_{t,t+1}(1-\vartheta-s_t)\Delta_{t+1}(W_{t+1}^*)\},$$

where $V_t^E(W_{i,t})$ is the value of the employed household member, $W_{i,t}$ is the wage, $P_i$ is the price of the good, $h_{i,t}$ is the number of hours worked, $b$ is unemployment benefits, $k^L$ is the positive scaling parameter of labor disutility, $\varphi > 0$ is the elasticity of labor supply, $\lambda_t$ is the marginal utility of consumption, $\beta_{t,t+1}$ is the discount factor, $\vartheta$ is the probability of dismissal, $\gamma$ is wage rigidity (the probability that the wage cannot be renegotiated), and $s_t$ is the probability of finding new employment.

Thus, the market value of a firm producing labor goods, which coincided with an employee receiving a nominal hourly wage, is equal to:

$$J_t(W_{i,t}) = \Psi_t^L(W_{i,t}) + (1-\vartheta)E_t\{\beta_{t,t+1}[\gamma J_{t+1}(W_{i,t}) + (1-\gamma)J_{t+1}(W_{t+1}^*)]\}.$$

where $\vartheta$ is the probability of dismissal, $\gamma$ is wage rigidity (the probability that the wage cannot be renegotiated), $J_t(W_{i,t})$ is the value of the firm, and $\Psi_t^L(W_{i,t})$ is the real profit of the firm, which is defined as:

$$\Psi_t^L(W_{i,t}) = x_t^L z_t h_{i,t}^{\alpha} - \frac{W_{i,t}}{P_t} h_{i,t} - \Phi.$$

$\Phi \geq 0$ represents the fixed cost of production for the period, while $x_t^L$ is the real price of the labor good. The second part of the equation indicates that firms that survive to the next period are subject to Calvo fluctuations: they can only negotiate the hourly wage with a certain probability, $1-\gamma$ .

For firms that negotiate deals during a specific period, the nominal hourly wage is determined through bargaining between the firm in the labor market and the worker:

$$\arg\max(W_{i,t})\ [\Delta_t(W_i, t\,)]^{\eta_t}[J_t(W_{i,t})]^{1-\eta_t} \Rightarrow W_t^*,$$

where $\eta_t$ represents the bargaining power of the household. In each period, the firm sets the optimal number of hours worked according to the marginal profit, where the marginal product of labor is equated to the real wage rate:

$$x_t^L z_t \alpha h_{i,t}^{\alpha-1} = \frac{W_{i,t}}{P_t},$$

$x_t^L$ the real price of labor goods, $h_{i,t}$the number of hours worked, $z_t$ – the technological shock, $\frac{W_{i,t}}{P_t}$ – the real wage.

Then, the first-order condition for the wage can be expressed as:

$$\eta_t J_t^* \frac{\partial\Delta(W_{it})}{\partial W_{i,t}}|^*\ W_t^* = (1-\eta_t)\Delta_t^* - \frac{\partial J(W_{i,t})}{\partial W_{i,t}}|^*\ W_t^*.$$

## VACANCY POSTING DECISION

The decision to post job vacancies is made by firms producing labor goods. Since the market is competitive and there are no entry barriers, the initial cost of posting a vacancy is reduced to zero. However, in equilibrium, the real cost of posting a vacancy $k > 0$,is defined as

$$k = q_t E_t\{\beta_{t,t+1} [\gamma J_{t+1}(W_t) + (1-\gamma) J_{t+1}(W_{t+1}^*)]\},$$

where $q_t$ is the probability of filling a specific vacancy, $J_t(W_{i,t})$ is the value of the firm, and $\gamma$ s the probability of not revising the wage. Newly opened positions face the same challenges as existing ones. That is, with a probability of $(1-\gamma)$, firms and workers can renegotiate a new wage rate. With the remaining probability $\gamma$, the wage is set equal to the wage from the previous period.

## 2.4. FISCAL AND MONETARY POLICY

The government budget constraint is defined as:

$$t_t + \frac{D_t}{P_t} = u_t b + \frac{D_{t-1}}{P_t} R_{t-1} e_{t-1}^b + g_t,$$

where the left side describes government revenues, and the right side of the equation refers to government expenditures. The government generates income from one-time taxes $t$. It also generates income through the issuance of new debt securities, $\frac{D_t}{P_t}$. $R_t$- is the nominal interest rate. The expenditure side includes unemployment benefits $b$, debt repayment and coupon payments, as well as government spending $g$. Government spending is an exogenous process and follows:

$$\log(g_t) = (1-\rho_g)\log(\bar{g}) + \rho_g \log(g_{t-1}) + e_t^g,$$

where $\rho_g \in [0,1), e_t^g \sim N(0, \sigma_g^2)$, $\bar{g}$ - a target level for government spending. Monetary policy controls the nominal interest rate $R_t$, in the form of a simple generalized Taylor-type rule, which effectively illustrates the monetary policy of many countries in recent years:

$$\log(R_t) = (1-\gamma_R)\log\left(\frac{\overline{\Pi}}{\beta}\right) + \gamma_R \log(R_{t-1})$$
$$+ (1-\gamma_R)\left[\frac{\gamma_\pi}{4}\log\left(\frac{\Pi_t^{YOY}}{\overline{\Pi}^4}\right) + \frac{\gamma_y}{4}\log(\frac{y_t}{y})\right] + \log(e_t^R),$$

where $\log(e_t^R) \sim N(0, \sigma_R^2)$ is an independent and identically distributed log-normally distributed shock to monetary policy. The monetary policy rule responds to the annual inflation rate and the output gap.$\overline{\Pi}$ represents the target inflation rate, $\Pi^{YOY}$ is the annual inflation rate. $\gamma_R \in [0,1), \gamma_\pi > 1, \gamma_y \geq 0$ are the response coefficients for the lagged interest rate, inflation, and output gap, respectively.

## 2.5. MARKET EQUILIBRIUM

Aggregate output is spent on personal and government consumption, vacancy placements, and fixed costs for the production of labor goods. Consequently, the resource constraint for the entire economy is defined as follows:

$$y_t = c_t + g_t + kv_t + n_t\Phi$$

where $y_t$ is the output, $c_t$- consumption, $g_t$- government spending, $v_t$- number of vacancies, $k$- cost of posting a vacancy, $\Phi$ - fixed costs of firms, $n_t$- employment level.

Market equilibrium requires that the demand for goods in each market equals the supply in that market. The equilibrium conditions for the retail and wholesale markets are defined as follows:

$$y_t = \left[\int_0^1 (y_{j,t})^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$$

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} y_t$$

The total demand for labor goods is defined by the equation $y_t^L = \int_0^1 y_{j,t}^{L,d} dj$ , where $y_{j,t}^{L,d}$ is the demand for labor goods by wholesale firm *j*. Market equilibrium for labor goods requires that demand equals supply, expressed as $y_t^L = z_t \int_0^{1-u_t} h_{i,t}^{\alpha} di$ .

The parameters for model calibration and steady state are detailed in Tables A1 and A2 in the Appendix.

## 3. WAGE CHANNEL AND TRANSMISSION OF MONETARY POLICY

In this section, the wage channel is described. As shown in the work of Christoffel et al. (2008), wages have a direct impact on inflation processes in the country. Specifically, the wages of both existing and new workers influence inflation through the search and matching process in the model. For simplicity, we set the wage rigidity parameter $\gamma$ equal to zero. Consequently, all firms pay the same wage rate, and all workers work the same number of hours. Under the right-to-manage concept, workers and firms negotiate only the hourly wage. At this wage level, the labor firm faces a perfectly elastic labor supply.

The first-order condition for hours worked equates the marginal value of the labor product to the real hourly wage:

$$x_t^L \alpha z_t h_t^{\alpha-1} = w_t,$$

Knowing that the marginal costs of the firm are equal to $mc_t = x_t^L$ and that the production function for labor goods firms is represented as $z_t h_t^{\alpha} = y_t^L$, we can rewrite the equation as:

$$mc_t = \frac{1}{\alpha}\frac{w_t h_t}{y_t^L},$$

where $w_t$ is the real wage, $h_t$ is the number of hours worked, $y_t^L$ is the production function for labor goods.

As a result, based on the above equation, a higher wage, all else being equal, leads to higher marginal costs for firms—and consequently, inflation. Conversely, wage rigidity, under similar conditions, results in stable marginal costs for firms setting prices. This stability leads to a muted inflation response to shocks. Thus, according to the equations presented, wages have a direct impact on inflation through the marginal costs of production. In the next section, we will present the calibrated model results for Kazakhstan and impulse responses based on different levels of wage rigidity.

## 4. RESULTS

In Graph 1, the impulse responses of key endogenous variables to a monetary policy shock are presented under various degrees of nominal wage rigidity. Wage rigidity indicates how prolonged the response of wage levels is to different changes and shocks in the economy. The graphs illustrate the shock transmission mechanism and the effectiveness of the transmission mechanism in the presence of frictions in the labor market.

The blue line in Graph 1 represents the baseline scenario, where wage rigidity is set at $\gamma = 0.8$. In this case, workers can renegotiate their wage contracts with employers every six quarters; in other words, the average duration of a wage contract is about six quarters.

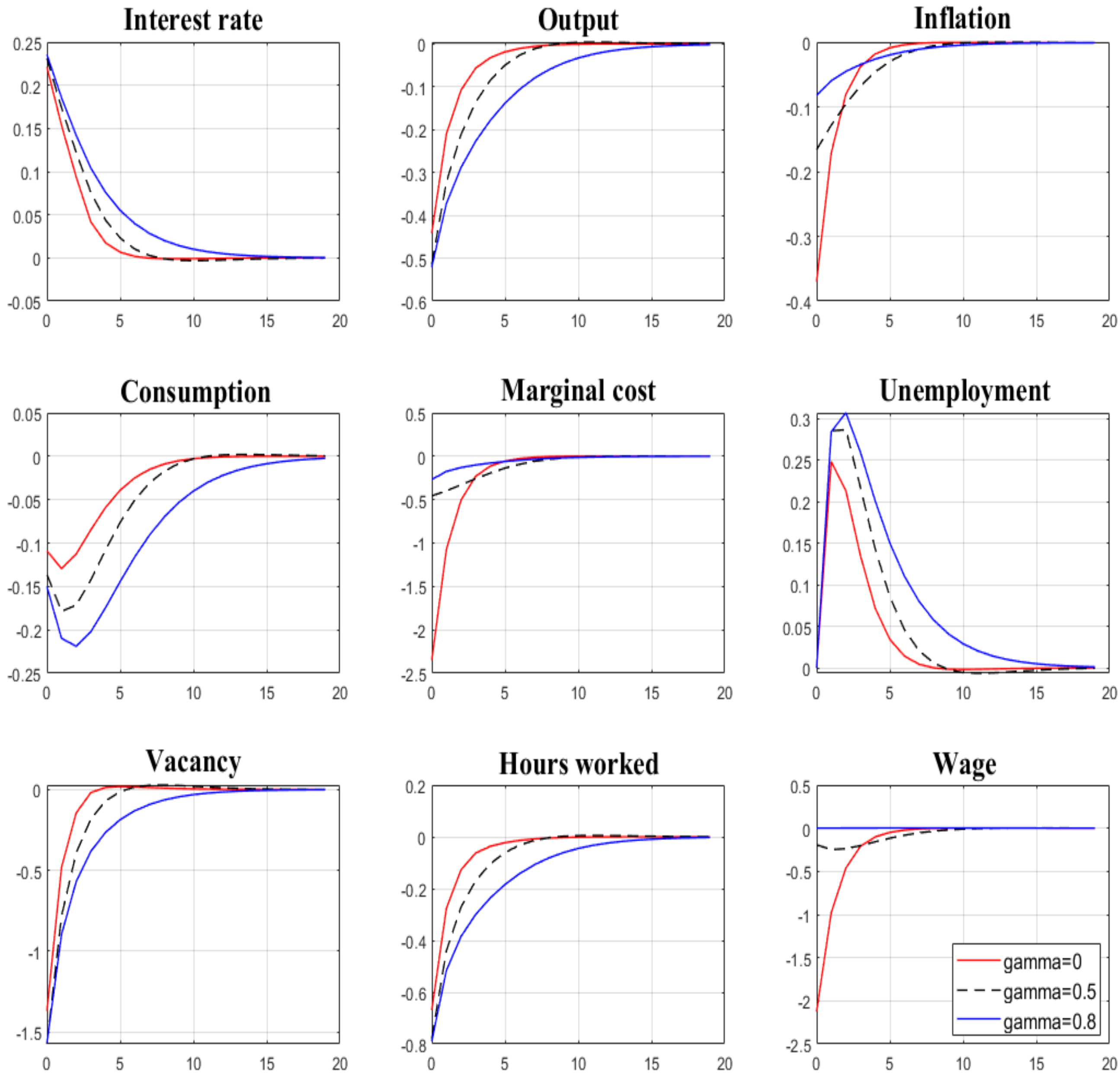
A higher interest rate, in the presence of nominal rigidity, leads to a higher real interest rate, which in turn encourages households to reduce consumption. The output responds accordingly: as consumption decreases, production declines (see Graph 1: Output). The reduction in production results in lower labor demands, meaning there is less demand for labor. Consequently, the adjustment of the workforce is initially achieved entirely through a reduction in hours worked per employee, as employment cannot decrease sharply. However, later on, due to the diminished demand for labor and the subsequent decline in expected profits in the labor sector, there is a drop in job vacancy postings. Ultimately, the number of hires decreases, leading to an increase in unemployment.

In anticipation of a tightening labor market and lower profits, the value of existing contracts decreases, and workers revising their contracts, may be willing to accept lower wages due to increased competition. However, since wages are reviewed every 6 quarters, a decline in output will have a negligible effect on wage reductions. As a result, the slight decrease in wages and drop in marginal production costs together imply a reduction in inflation following a tightening of monetary policy (see the blue line in Graph 1: Inflation).

The black dashed line in Graph 1 shows the economy's response to the tightening of monetary policy when wages are reviewed an average of twice a year ($\gamma = 0.5$). The case of fully flexible wages ($\gamma = 0$) is depicted by the red line, where wage adjustments occur immediately in response to economic changes. All other parameters remain at their baseline values. Real wage rates decrease more sharply when nominal wages are more flexible, suggesting a more significant drop in marginal costs. Consequently, the initial response of inflation will be greater, while the output response will be weaker.

Thus, the more flexible the wages, the stronger the impact of monetary policy on inflation. Additionally, less rigid wages also lead to less stable inflation. Therefore, inflation inertia is also a consequence of wage rigidity: the more rigid the wages, the higher the inflation inertia.

**Graph 1. Impulse Responses to a 25 Basis Points Monetary Policy Shock: Nominal Wage Rigidity**




Note: The graphs show percentage responses (number 1 corresponds to a 1% increase compared to the steady state value) of endogenous variables to a 0.25% tightening of monetary policy under different wage rigidity levels. The time period is one quarter. The blue solid line represents the calibrated baseline model (γ=0.8, with an average wage contract duration of 6 quarters). The black dashed line illustrates a scenario of lower wage rigidity (γ=0.5, average contract duration of 2 quarters). The red line corresponds to the case of no wage rigidity (γ=0). Wage rigidity refers to the inflexibility of wages over a specific period. For example, higher wage rigidity means wages are indexed less frequently.

Source: *Author's calculations.*

## 5. CONCLUSION

In conclusion, this article examines the impact of wage rigidity on inflation within the framework of monetary policy transmission using the New Keynesian business cycle model with labor market rigidity, as developed by Christoffel et al.

(2008). The model establishes a link between wages and inflation, which is a central feature of economic models utilized by central banks. The results indicate that the significance of labor market rigidity for the business cycle and the transmission of monetary policy largely depends on the nature of that rigidity. A more flexible labor market environment, characterized by a lower degree of wage rigidity, leads to a quicker reduction in inflation following a tightening of monetary policy.

This study serves as a foundational dynamic stochastic general equilibrium model. Future research should focus on estimating the model parameters using Bayesian methods, which would facilitate the examination of shock impacts on key macroeconomic variables based on empirical data. The model presented in this research aims to analyze the labor market in Kazakhstan. However, for further enhancement, the model should be expanded to incorporate features of an oil-exporting country, external trade relations, the differentiation of Ricardian and non-Ricardian households, and other characteristics specific to the Kazakh economy.

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# APPENDIX

## A1. MODEL CALIBRATION

| PARAMETER | VALUE | DEFINITION |
|---|---|---|
| $\boldsymbol{\beta}$ | 0.99 | Time-discount factor; |
| $\boldsymbol{\varrho}$ | 0.65 | External habit persistence; close to Smets and Wouters (2003). |
| $\boldsymbol{\sigma}$ | 2.71 | Risk aversion; Adilkhanova (2019). |
| $\boldsymbol{\varphi}$ | 2.11 | Inverse Frisch elasticity of labor supply; Adilkhanova (2019). |
| $\boldsymbol{\alpha}$ | 0.66 | Labor elasticity of production; targets labor share of 60% |
| $\boldsymbol{\xi}$ | 0.70 | Elasticity of matches w.r.t. unemployment; |
| $\boldsymbol{\sigma_m}$ | 0.15 | Efficiency of matching; |
| $\boldsymbol{\eta}$ | 0.5 | Bargaining power of workers; Christoffel et al. (2008). |
| $\boldsymbol{k}$ | 0.242 | Vacancy posting costs; Tolepbergen (2021). |
| $\boldsymbol{\gamma}$ | 0.8 | Avg. duration of wages contracts of 6 qtrs.; Christoffel et al. (2009). |
| $\boldsymbol{\xi_w}$ | 0 | Wage indexation; no indexation in the baseline model. |
| $\boldsymbol{\vartheta}$ | 0.068 | Quarterly separation rate, average for 2016-2023; BNS ASPR RK |
| $\boldsymbol{\omega}$ | 0.75 | Average duration of price contracts; target is 4 quarters; |
| $\boldsymbol{\Phi}$ | 0.0092 | Fixed costs of firms; Christoffel et al. (2008). |
| $\boldsymbol{\xi_p}$ | 0 | Price indexation; no indexation in the baseline model. |
| $\boldsymbol{\epsilon}$ | 11 | Price markup; target steady-state value is 10%. |
| $\boldsymbol{\gamma_R}$ | 0.85 | Interest rate smoothing coefficient; Christoffel et al. (2008). |
| $\boldsymbol{\gamma_\pi}$ | 1.5 | Response to inflation; Christoffel et al. (2008). |
| $\boldsymbol{\gamma_y}$ | 0.5 | Response to the output gap; Christoffel et al. (2008). |
| $\boldsymbol{\overline{g}}$ | 0.12 | Government expenditures; targets the ratio of government spending to GDP (quarterly average 1995-2023). |
| $\boldsymbol{b}$ | 0.257 | Unemployment benefits; target replacement rate is 40%. |
| $\boldsymbol{\rho_b}$ | 0.8 | AR(1) risk premium shock; Christoffel et al. (2009). |
| $\boldsymbol{\rho_g}$ | 0.34 | AR(1) government spending; |
| $\boldsymbol{\rho_z}$ | 0.48 | AR(1) technology shock; |
| $\boldsymbol{\sigma_b}$ | 0.218 | Standard deviation of innovations to the risk premium shock; |
| $\boldsymbol{\sigma_R}$ | 0.658 | Standard deviation of innovations to the Taylor rule; |
| $\boldsymbol{\sigma_g}$ | 0.15 | Standard deviation of innovations to government spending; |
| $\boldsymbol{\sigma_z}$ | 0.049 | Standard deviation of innovations to technology. |

A2. STADY STATE

| PARAMETER | VALUE | DEFINITION |
|---|---|---|
| $\boldsymbol{y}$ | 1 | Output |
| $\boldsymbol{c}$ | 0.87 | Consumption |
| $\boldsymbol{u}$ | 0.101 | Alternative unemployment rate, corresponding to the average unemployment rate from 2013-2023; BNS ASPR RK, author's calculations |
| $\boldsymbol{v}$ | 0.009 | Vacancies (relative to the labor force); enbek.kz, BNS ASPR RK, author's calculations |
| $\boldsymbol{s}$ | 0.08 | Probability of finding a job |
| $\boldsymbol{q}$ | 0.7 | Probability of finding a worker |
| $\boldsymbol{\frac{b}{wh}}$ | 0.4 | Unemployment replacement ratio |