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Impact of tax changes on the risk premium of the WIG index

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Abstract

The presented article provides an empirical analysis of changes in the risk premium of stocks on the Warsaw Stock Exchange in response to changes in tax rates. The analysis uses a structural VAR model, identified with sign restrictions. This method turns out simple to use and proves to be effective in overcoming the problem of predictability of fiscal policy, which is especially important in studies using variables from financial markets. The results show an increase in the risk premium following a sudden tax hike, accompanied only by a temporary reduction in GDP growth. Meanwhile, an anticipated tax hike seems to lower risk premia while being more harmful to GDP dynamics.

Keywords: fiscal policy, risk premium, VAR model, sign restrictions, behavioural finance

JEL: C32, C58, G12, G41, H30

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1. Introduction

The risk premia, understood as the additional expected rate of return over the risk-free rate that an investor can expect for taking a risk, is one of the most important parameters needed to assess the attractiveness of an investment. Short and mid-term variation in individuals' risk premia are usually linked to changes in income and consumption[1] or behavioural factors, while in the long term it varies also due to investor's age. Therefore, any shocks that can affect these variables may influence risk premia as well. One of the most important shocks that can affect the economy is a change in taxes. It affects both household disposable income and the expected after-tax rate of return on investments.

Despite the importance of risk premiums and tax changes, their joint analysis is rare in studies for Poland. One exception is an article by Radwański (2019), which uses a narrative variable and finds an increase in risk premium in response to tax increases. This is in line with economic intuition and theory, but the accuracy of estimates based on narrative variables is always derived from the "quality" of the variable used by which the results should be treated with caution.

The main purpose of the following article is to empirically analyse the impact of tax changes on the risk premium of the WIG index. For this purpose, a vector autoregression model was used, in which tax shocks were identified using sign restrictions. An additional objective of the study is to see whether the identification of tax shocks by this method can be an alternative to more complex methods, based on narrative variables. To facilitate comparisons, the model used in this article was built with variables used by Radwański (2019), which identifies tax shocks using a narrative variable.

The estimated results show a strong increase in the risk premium after the tax rate hike, while GDP dynamic is initially falling. The premium later falls gradually toward the baseline scenario, while GDP growth recovers even faster and exceeds the baseline scenario over a few quarters. As the results obtained in this article are similar to Radwański (2019) sign restrictions seems an effective alternative to narrative variables. At the same time, this method offers greater flexibility and does not entail the risk of measurement errors found in narrative time series.

2. Literature review

The effect of tax changes on the risk premium is usually analysed indirectly, i.e. through the links of taxes, or fiscal policy in general, with the real sphere of the economy and through the links of real variables with the stock market.

An important group of studies linking taxes to the real sphere of the economy are analyses of the fiscal multiplier, which determines the effectiveness of stimulating the economy with fiscal policy. Blanchard and Perotti (2002) find that both tax cuts and increases in government spending increase GDP, yet with estimated multipliers being close to unity. Mountford and Uhlig (2009) propose a method for analysing fiscal impulses with the VAR model and sign restrictions. Like Blanchard and Perotti (2002), the authors find an increase in GDP following deficit-financed increases in government spending as well as tax cuts, with the stimulus effect being much stronger for tax cuts. The stimulative effect of tax cuts on GDP is also found by Romer and Romer (2010), who use a narrative method to identify the VAR model.

[1] The importance of consumption to the risk premium is highlighted by the consumption-based CAPM theory, discussed by Wickens (2011), among others.

Empirical results for estimating the size of the fiscal multiplier and the relationship between tax changes and the overall economy can vary depending on the data used, and more specifically, depending on the country involved. Afonso and Sousa (2012) find the existence of a Keynesian fiscal multiplier in the United States and the United Kingdom, and the possibility of a new-Keynesian multiplier in Italy and Germany.[2] In addition to the effect on GDP, they analyse the response of financial asset prices and find a negative response to increased spending, in each of the countries analysed. Differences between countries are also pointed out by Wierzbowska and Shibamoto (2018). Analysing a group of countries, both developed and developing, they find that the size of the fiscal multiplier depends on the openness of the economy and the freedom of capital flows, among other factors.

Croce, Kung and Nguyen (2012), on the other hand, analyse the uncertainty associated with future income tax changes on firms' decisions and the value of financial assets using a general equilibrium model that incorporates risk aversion. In doing so, they point to three main channels for the impact of tax changes. The first is the profit channel, which is the ability of companies to make investments. The second is the tax shield, resulting in a lower cost of debt following a tax increase. The third channel is a reduction in productivity growth following a tax increase. The results indicate that both the tax rate increase itself and the uncertainty about its future effects adversely affect the cost of capital (growth) and the level of investment. In another article by Croce et al. (2019), the authors confirm the existence of an adverse effect of uncertainty on investment, and further note that tax increases can be particularly detrimental to investment in research and development.

Stock risk premium itself, on the other hand, is often analysed using factor models. Fama and French (1992) find that the stock risk premium is shaped by three factors: small minus big (SMB), high minus low (HML) and market.[3] Interestingly, Vassalou (2003) finds that the SMB and HML factors can be completely pushed out of the premium model if information about the future growth of the economy is introduced into the model. This suggests that macroeconomic variables can act as "factors" to explain the risk premium. A similar conclusion is provided by Lettau, Ludvigson and Wachter (2008), who link fluctuations in the risk premium to fluctuations in real variables. Wachter (2013), on the other hand, points to the risk of a significant decline in consumption, for which investors expect an additional premium. Conclusions from this group of literature confirm that changes in fiscal policy can affect the risk premium, as long as we assume that fiscal stimulus can affect the state of the economy and changes in consumption.

The literature on stock risk premium also links its changes to general uncertainty about future fiscal policy decisions. Pastor and Veronesi (2012) analyse the stock market's response to stimulus from broadly defined economic policies (not only taxes) and find two effects. The first results in a decrease in risk premium, which the authors link to the fact that the actions taken by government are usually aimed at eliminating existing disadvantages, such as improving income distribution. The second effect works in the opposite direction, which the authors link to an increase in uncertainty about the effectiveness of newly taken actions. The strength of the first effect depends, according to the authors, on the phase of the business cycle and the extent to which the changes being made will be considered beneficial, with the second effect being stronger on average.

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[2] The term new-Keynesian is usually used to refer to models that assume the rationality of economic agents' expectations, but allow for price and wage rigidity.

[3] SMB means the difference in the return of small and large companies. The HML factor means the difference in the return of companies with high and low price-to-book value ratios. Market is understood as the return on the entire market, over the risk-free rate.

A similar issue is discussed by Kelly, Pastor and Veronesi (2016) who analyse the effects of political uncertainty on the market pricing of risk in the stock market. The authors use the volatility implied by an option pricing model, in periods around important events, such as elections or political-economic summits. The results indicate that elevated political uncertainty, as a non-diversifiable factor, implies an increase in the risk premium, which is greater the weaker the current economic environment.

Krishnamurthy and Vissing-Jorgensen (2012), on the other hand, point out that the increase in Treasury debt required to finance the fiscal stimulus must lead to higher market interest rates to attract additional demand for the bond market. Economic agents then reallocate their portfolios from equities toward bonds, leading to an increase in the expected return on risky instruments. The results indicate, however, that the magnitude of this effect is smaller than the increase in bond yields following the increase in bond supply, making the risk premium of equities[4] decline. Similar results are obtained by Gomes, Michaelides and Polkovnichenko (2013).

The effect of tax changes on the premium is also found by Kraus and Winter (2016), with an emphasis on the role of financial intermediaries. Using a narrative method, they show that an increase in income tax rates leads to an increase in corporate bond premiums,[5] which the authors link to changes in the cost and supply of credit.

Among the research utilizing data from the Polish economy, Radwański (2019) uses a narrative variable to identify tax shocks in a VAR model. The author finds an increase in the risk premium following a tax increase, although its adverse effect on real economic growth turns out to be short-lived. Narrative variables are also used by Haug, Jędrzejowicz and Sznajderska (2013), who, however, find no significant difference in results between a model in which the narrative variable is omitted.

Risk premia on Polish stocks is attempted also by Zaremba and Konieczka (2017). The authors analyse the risk premium in 2001–2014, testing three popular models: CAPM, Fama and French's three-factor model and Carhart's model.[6] The authors find the significance of the HML factor, especially in the group of small companies-and WML (winners minus losers), whose influence is strongest in the entire group of companies analysed, and especially in the case of large companies. The results from the analysis, on the other hand, indicate the insignificance of the SMB factor, while suggesting the rejection of the CAPM model. An interesting observation made by the authors is the high correlation of the momentum with the factors responsible for the risk premium in selected foreign markets, which is most likely due to the large share of foreign investors treating Poland as part of a broader portfolio.

Summarizing the results in the literature discussed above, it can be said that tax impulses can affect the equity risk premium through at least two channels. The first is the impact of tax changes on the economy, in which the multiplier mechanism or uncertainty about the future effects plays a role. Moreover, it seems important whether current fiscal decisions will force adjustments in the future. Macroeconomic variables, in turn, can directly shape risk premia as indicated by models that use

[4] The premium in this case is defined as the difference between the expected return on stocks and the yield on government bonds.

[5] The risk premium on corporate bonds is positively correlated with the risk premium on stocks, since the bond issuers in this case are private entities, often listed on stock exchanges. Increased interest in bonds issued by companies usually coincides with higher interest in their stocks.

[6] Carhart model takes into account market dynamics (momentum) in the form of an additional WML factor. The WML factor is defined as the difference between the cumulative return achieved over the past 12 months by companies that have risen over that period and those whose stock price has fallen.

economic variables as factors. The effects of tax changes on the economy can, however, vary depending on the current state of public finances, the degree of openness of the economy or what role foreign investors play in it. Differences can also exist between developed and emerging markets.

3. Data

The joint analysis of taxes and risk premium requires the estimation of a risk premia, which series is not directly observable. Similar to Radwański (2019), in this article, the risk premia is estimated following Neely et al. (2014), who use fundamental variables popular in the literature[7] as well as some popular technical indicators.[8] The method is based on a prediction equation of the form:

$$r_{t,t+1} - r_{f,t,t+1} = \alpha + \sum_i \beta_i PC_{i,t} + \mu_{t+1} \tag{1}$$

where

- $r_{t,t+1}$ – a log return on WIG index from t to $t+1$,
- $r_{f,t,t+1}$ – monthly Wibor rate at t until $t+1$,
- $PC_{i,t}$ – the value of i principal component at time t, determined on a broad group of financial, macroeconomic indicators and technical analysis signals,
- μ – the random component; denotes that part of the index's volatility that is not explained by the principal components.

The prediction equation describes the rate of return that rational investors can expect from an investment in the WIG index over the risk-free rate, given the information contained in the determined principal components. Thus, the values fitted by the equation represent the risk premium.

The predictive equation was estimated with monthly data and quarterly risk premia was later calculated by summing the respective months. Estimated results are presented in Table 1, which also shows the results of the bootstrap simulation.[9] The determined risk premium series is shown in Figure 1, along with the other variables used later in the VAR model.

The model used in the remainder of the article was built similarly to Radwański's (2019) article, based on six variables: central budget tax revenues, central budget expenditures, gross domestic product, consumer price index, average Wibor rate and an estimated series of risk premia. Tax revenues

[7] The set of fundamental variables used included ratios: dividend/price ratio, dividend/price (t –12) (dividend yield), inverse of earnings-price ratio, dividend payout ratio, annual standard deviation of index returns (volatility), net new issues/capitalisation (net equity expansion), one-month Wibor rate, 10-year benchmark government bond yields and their annual return, the difference between 10-year and one-month deposit yields, the one-month lagged annual CPI inflation rate.

[8] A total of 14 technical indicators generating a buy signal based on short- and long-term averages, market dynamics (momentum) and changes in trading volume (on balance volume). In each case, the buy and sell signal was expressed as a 0/1 variable for selling and buying, respectively. In the case of moving averages, a buy or sell signal is generated depending on whether the short-term average is greater than the long-term average. The analysis uses short-term averages: monthly, two-month and three-month, as well as long-term averages: nine-month and one-year. Indicators of market dynamics (momentum) are based on comparing the current value of the index with that of several periods ago. Periods of 9 and 12 months were used. The OBV indicator is created by assigning the volume of transactions in a given period a value of -1 or 1, depending on whether the price fell or rose. The volume series constructed in this way are then averaged, and the short-period averages are compared with the long-period averages. The same combinations of averages were used as in the analysis of index-level averages.

[9] OLS estimation of predictive equation is subject to the so-called Stambaugh bias. Bootstrap simulation addresses this problem, while simultaneously dealing with possible heteroscedasticity and non-normality.

were determined as the sum of VAT, PIT, CIT and excise revenues. The total amount of state budget expenditures was used as a measure of expenditures.[10] The series of gross domestic product, gross fixed capital formation and budget taxes and expenditures are presented in terms of per capita,[11] transformed into volumes with the GDP deflator[12] and seasonally adjusted.

Stationarity tests showed that for the constructed variables (except for the risk premium), the hypothesis of the existence of a unit root could not be rejected. In the case of Wibor1M, the p-value was relatively high, at 6.8% or 15.6%, a trend in data that was assumed. In the baseline specification Wibor1M was assumed non-stationary and the change of this assumption was later tested as a robustness check. In the baseline specification the variables were logarithmized (except for Wibor1M), and differentiated. All variables are presented in percentage points.

Based on the analysis of the SC, AIC as well as HQ information criteria, as well as the criterion of no residual autocorrelation, a VAR model with three lags was selected. Statistical tests indicated suggested rejection of the hypothesis of normality of the random component. The problem remained even with larger number of lags and disappeared only after removing some observations that in the author's opinion should, however, remain in the sample,[13] so not meeting the normality assumption was finally accepted. The historical values of the series used are shown in Figure 1.

In parallel with stationarity, an analysis of the long-term relationships between the model variables was carried out. The Johansen procedure did not yield conclusive results, however. Depending on the number of lags and the variant of the cointegrating equation,[14] the test indicated the existence of from at most two to a maximum of four cointegrating relationships (Table 2).

Mixed results of the test suggest caution when analysing cointegration between the variables. Lin and Tsay (1996) indicate that when the true number of cointegrating vectors is unknown, it may be best to omit long-run relationships from the model. Gonzalo and Lee (1998), on the other hand, indicate that the Johansen test tends to find too many cointegrating vectors, which are in fact spurious correlations. It was therefore decided not to include cointegrating relationships in the model. The omission of cointegration is also supported by the relatively short period of time over which the analysis is performed, with the Polish economy also experiencing significant disturbances, such as the financial crisis of 2009 or covid pandemic.

4. Identification of fiscal impulses

Identifying tax impulses in the VAR model carries three problems. The first is the large number of regulatory variables that determine tax revenues. Tax receipts can also change on their own, solely

[10] Central budget spending includes both current and capital expenditures.

[11] The use of GDP per capita is reasonable if we assume that the holdings of individuals and their expected changes influence capital allocation decisions between risky and safe assets.

[12] Constant 2010 prices.

[13] The maximum lag that has been tested is six quarters. Further increasing the number of lags reduces the number of degrees of freedom and the accuracy of the estimates. Obtaining a random component with a normal distribution would require removing one-time events from the sample, including the first quarter of 2009 (and thus at the height of the global financial crisis) for interbank interest rate data and the collapse of GDP in the second quarter of 2020 (the shutdown of the economy due to a pandemic). However, these periods appear valuable for information on the relationship between risk premiums and GDP dynamics, and thus were not excluded from the analysis.

[14] Typically, five variants of the Johansen test are analysed, depending on assumptions about the constant and the presence of a trend in the data. In this article the appropriate form of the test is the variant allowing a linear trend in the data and a constant in the cointegrating equation.

due to economic fluctuations. Romer and Romer (2010) point out that this problem can be limited by ridding tax receipts of the components that can considered cyclical. Even assuming that such an adjustment is sufficiently accurate, building a model that fully describes changes in all kinds of tax receipts would still require the inclusion of a great many variables, which is almost impossible.

The second problem in measuring the impact of taxes is the predictability of fiscal policy (fiscal foresight) as economic agents can predict future changes in policy, basing on current tax revenues, the structure of spending and the economic outlook. This results in underestimation of fiscal policy effects. An example is the government's countercyclical fiscal policy. In such a situation, investors will expect a tax increase/cut whenever the economy enters a recovery/deceleration and will adjust their decisions. Assuming that such policies are effective, i.e. they smooth out economic fluctuations, the impact of tax changes on GDP will appear to be small (Romer, Romer 2010).

Measuring the impact of tax changes on the economy is also hampered by the existence of long lags between the introduction of changes and their implementation. Some of the new decisions may be discussed long before the legislation process starts. It means that the impact of changes, even those that can be considered exogenous to macroeconomic variables, can be difficult to measure, as agents adjust to them much earlier, which results in similar issues as with fiscal foresight.

Based on the experience of the Polish tax system, the issue of tax system efficiency also seems important. A particular example is the so-called VAT gap.[15] Sealing the tax system may lead to an increase in tax collections even without hiking the tax rate.[16] This is particularly important in analyses based on narrative variables. They are based on the estimated effects of actual tax decisions which were estimated prior to the introduction of tax changes, e.g. at the impact assessment stage. With significant leakage in the system, actual tax collections will be lower than planned, reducing the accuracy of the narrative variable and underestimating the impact of tax changes.

The literature proposes two approaches to the problems presented. The first, popularized by Romer and Romer (2010), is a narrative analysis, based on the selection of those tax changes that can actually be considered fully exogenous. This approach is also sometimes combined with the SVAR models, as Radwański (2019) or Mertens and Ravn (2013).

The second approach assumes model identification by sign restriction. This method, introduced by Mountford and Uhlig (2009), consists of repeatedly shocking the VAR model with random orthogonal shocks, and then leaving only those models whose impulse responses satisfy a given sign criterion. This approach is characterized by high flexibility in the analysis of different shocks and is free from the problem of data availability and accuracy. Because of these features, as well as for the comparison of the two approaches, this article uses sign restrictions for tax shock identification.

5. Sign restrictions

The general specification of the structural vector autorepression model[17] (SVAR) is:

$$AY_t = \sum_j Z_j Y_{t-j} + S\varepsilon_t = \sum_j Z_j L^j Y_t + S\varepsilon_t \tag{2}$$

[15] The VAT gap is defined as the difference between VAT received and VAT due.
[16] The topic of the tightness of the tax system in Poland is discussed in detail by Mazur et al. (2019), among others.
[17] To simplify the notation, the constant was omitted. All models estimated in the rest of the article include a constant, however.

where:

$(j \geq 1)$ – the lag order, A, S i Z_j contain model parameters,

L^j – the lag operator of order j such that $L^j Y_t = Y_{t-j}$,

$\varepsilon_t \sim N(0, I)$ – the vector of structural innovations.

Matrix A determines the relationships that occur between the variables of the model during the same period, Z_j contains parameters at observations lagged by j observations, while diagonal matrix S contains standard deviations of structural innovations. We can also rewrite the above model in a reduced form (VAR):

$$Y_t = \sum_j C_j L^j Y_t + B\varepsilon_t = \sum_j C_j L^j Y_t + u_t \tag{3}$$

where:

$$u_t = B\varepsilon_t \tag{4}$$

Vector u_t contains random components derived from a multivariate normal distribution N (0, Ω). Expressing the model in reduced form is convenient because of the parameter estimation process. Unfortunately, identification of the model requires assumptions about $n(n–1)/2$ elements of B. In a great many cases, it is difficult to unambiguously determine the best identification scheme, since the relationships between macroeconomic variables are often bilateral and, moreover, can vary depending on the frequency of the data used.

Identifying a VAR model using sign restrictions can be considered an answer to the problem of selecting a single best set of restrictions. Not being sure which set of restrictions is the best, one should consider as many models as possible, any of which may be the right one. In practice, this involves determining a number of response functions and then selecting those that satisfy the restrictions specified at the beginning of the study in either a positive or negative sign. Imposing restrictions on the sign only requires determining the direction in which the selected variables should respond, rather than determining the strength of the relationships between them, as in the case of short-, or long-term restrictions. The sign of the reaction function is usually determined on the basis of economic theory. For example, when considering the effect of a technological stimulus on economic growth, it can be assumed positive. However, the method does not require determining the direction of the relationship between all variables. It is sufficient to determine the sign only where it can actually be determined a priori.

The method also has the advantage of being able to impose restrictions at any time from the onset of the shock. This makes it possible to obtain the response of the model to any impulse defined by the researcher, provided, of course, that any of the response functions meets the criteria.[18] In the context of fiscal impulse analysis, the method allows anticipated tax shock to be analysed,

[18] A small percentage of response functions meeting the set criteria is sometimes taken as a signal that the adopted restrictions may not correspond to the real relationships that occur between the modelled variables. On the other hand *t* system can by disturbed by a great number of various shocks, so when filtering only the desired responses, one should in fact expect only a small percentage of successful draws.

similarly to Mountford and Uhlig (2009).[19] The authors compare the results obtained from their basic model with the impulse expected one year after the announcement, which corresponds to imposing positive restrictions on the taxes only from the fifth quarter.

5.1. The method

The starting point is $u_t = B\varepsilon_t$, that links reduced form residuals u_t and structural shocks ε_t. This can be rewritten as:

$$u_t = BQ'Q\varepsilon_t = T\eta_t \tag{5}$$

where $T = BQ'$, while Q orthogonal matrix such that $Q'Q = QQ' = I$.

Thus, $\eta_t = Q\varepsilon_t$ contains structural residuals transformed with Q such that, $\eta_t \sim (0, \mathrm{I})$. Matrix B can be derived from any model identification scheme that does not necessarily correspond to the true relationships between variables. A common practice is to use Cholesky decomposition for this purpose. To know Q is enough to identify VAR as matrix T determines the model reaction to structural shock η_t, while its elements depend on Q and B, which are known. The model in reduced form (3) can be rewritten as:

$$Y_t = \sum_{j=1}^{n} C_j L^j Y_t + T\eta_t \tag{6}$$

Model identification, however, in this case proceeds in reverse order. First, the impulse responses are analysed. Then the selected matrixes B and Q can be used to recover the parameters of structural form. In the “traditional” approach, assumptions are first made about the immediate relationships between the variables, and only later are the impulse responses analysed.

Matrix Q is crucial for identification which, thanks to the property of orthogonality, makes it possible to draw independent shocks. The determination of Q can be based on several methods, the most popular of which are the Givens matrix and the Hausholder transformation. In this article, due to the ease of implementation, the second method is used.[20]

Householder transformation

Householder transformation allows decomposition of square matrix Θ with real elements into upper triangular matrix R and orthogonal matrix Q:

$$\Theta = QR \tag{7}$$

Thus, in the case of the Householder transformation, the determination of structural shocks involves drawing multiple square matrices with elements derived from a distribution of $N(0, 1)$ and

[19] This requires imposing the restriction that the response function can take on positive values only after several periods following the shock.

[20] The determination of the Q matrix was performed in Python using the numPy package’s linalg.qr function. The results obtained were very similar to those obtained with a VBA macro in the excel package, using Givens rotations.

the number of rows corresponding to the number of variables in the model. These matrices are then decomposed and the orthogonal matrix Q is used to construct a new shock.

Median target

The next step, after determining the restrictions and drawing a set of response functions, is to choose an inference method. Uhlig (2005) suggests determining the median of all response functions meeting the given criteria and treating it as the most likely response of the model to the given shock. The estimated set of response functions can also be used to measure the uncertainty of this estimation, e.g. by determining dispersion measures. Uhlig (2005) proposes to determine selected percentiles and present them together with the median.

However, this approach is increasingly rare in empirical studies. Fry and Pagan (2011) point out that the median of the response function is determined for each period (month, quarter, year) since the onset of the shock, which means that its values in subsequent periods come from different draws, and therefore from different models. The same applies to any percentiles determined from the drawn response functions. Thus, the median should not be treated as a response function derived from a single most likely model, and the estimation of percentiles should not be confused with the traditional determination of a confidence interval around a response function. In fact, these measures only show the spread of results between all draws. Fry and Pagan (2011) suggest using only one response function, being the closest to the median of all response functions that met the sign restrictions. The response function determined this way is referred to by the authors as the median target.

When analysing a single shock in a VAR with six variables, from each "successful" draw, we get six response functions, standardised against the median, whose values are then squared and summed. The model for which the resulting sum is the smallest is referred to as the median target.

6. Empirical analysis

The restrictions adopted in this article are analogous to the approach used by Mountford and Uhlig (2009). They assume that the response of tax revenues to their unexpected increase should be positive over a horizon of four quarters from the onset of the shock.[21] This is to eliminate short-term shocks to tax revenues. As in Mountford and Uhlig (2005), no restrictions are imposed on the response function of budget spending dynamics following tax increases.

Another assumption is the negative sign of the GDP dynamics response function following a tax increase. This is to reject those changes in tax revenues that may be due to changes in economic growth, especially those of a cyclical nature. In addition, higher taxes are usually treated as a disincentive to economic activity, i.e. they should reduce the rate of GDP growth. Given the ambiguous findings in economic theory, no restrictions have been placed on the risk premium function, consumer price dynamics and changes in deposit rates.

[21] A variant of the model was also analysed, in which positive restrictions on the tax response function to their sudden increase applied only to the first period. The results obtained were similar to those obtained from the presented version of the model. Mountford and Uhlig (2009) analyse the robustness of the results obtained to changes in this assumption, imposing restrictions only on the first period of the response function, and find that this does not significantly affect the results.

In addition to the basic version of the model, a scenario in which a tax increase is expected a year before it takes effect was analysed. Mountford and Uhlig (2009), who also analyse anticipatory shocks, impose zero restrictions on the first four periods of the tax revenue response function and assume a positive sign after four quarters. In this article, however, no restrictions are placed on the tax response over the first year. This allows for a scenario in which the announcement of the tax hike affects the economy, and so tax revenues.[22] All imposed restrictions are summarized in Table 3.

The results of the simulation based on the VAR model are shown in Figure 2. The response of GDP dynamics to an unexpected tax increase is negative, although short-lived. The course of the response function, defined as the median target, indicates that GDP dynamics initially decreases by about 0.15 percentage points.[23] Increasing taxes seem to have limited impact on the CPI, the reaction of which is small and associated with large uncertainty, measured with IRFs' dispersion.

An important observation is the rapid return of GDP growth to values above the baseline scenario, even without any positive effect on public spending. Economic growth, despite the initial decline, thus appears resilient to tax increases. A stabilizing factor for GDP dynamics may be the issue of uncertainty, or more precisely, its reduction. This is because fiscal tightening may result in lower concerns about the state of public finances, while giving the government more room for future stimulus, if needed.[24] Such a situation can support economic growth, as reported by Croce, Kung and Nguyen (2012).

The response of the risk premium is already strongly positive (1.8 percentage points) when the shock occurs. The increase in the premium is consistent with macroeconomic theory, according to which an increase in taxes is bad for income and consumption. The premium starts to fall immediately towards the base case scenario, which can be linked to improving GDP dynamics. The return to the baseline scenario is, however, slower than in case of GDP. This pattern is interesting because it may suggest that uncertainty over the final effects of rising taxes is persistent, contrary to GDP. If so, a strong jump in risk premia can be considered a good investment opportunity.

The resulting response functions can be compared with results based on other identification methods. Radwański (2019) finds that the increase in premiums following a 1% tax increase reaches about 1.5 percentage points, which is comparable to the results from sign restrictions. The other response functions also follow a similar pattern. Thus, sign restrictions seem to correctly address the problem of fiscal foresight, while being much easier to use compared to a narrative method.

Sign restrictions allow analysis of a scenario in which tax increases are announced long before implementation, making fiscal policy predictable (Figure 3). The announcement of a tax hike has no effect on public spending or inflation, but it lowers the rate of GDP growth. This suggests that a government that plans to raise taxes in the future should therefore expect a temporary weakening of economic growth and a lower rate of growth in tax revenues long before the tax increase itself. Somewhat surprising in this scenario is the initial decline in the risk premium, which only increases in subsequent periods as the timing of the tax increase approaches. This effect cannot be linked to an increase in interest rates, which also occurs in this scenario, but its magnitude is much lower. The effect of a tax shock on risk premia is therefore different from the previous scenario, when the premium rose as a result of a tax hike.

[22] The approach adopted in this work is, in the author's opinion, closer to economic intuition since it does not exclude the situation in which tax revenues will increase in anticipation of a tax increase.

[23] Initial shock to tax revenues is close to 0.1%. Over the first 4 quarters tax revenues exceed the baseline scenario by about 0.80%. Based on 2022 tax revenues (PIT, CIT, VAT, excise), the (annual) shock is close to PLN 3.6 bn.

[24] Over the sample period, Poland's general government deficit was relatively high and often exceeded the 3% GDP limit given by EU regulations.

This result can be explained by different expectations about the ultimate results of the tax increase. Pastor and Veronesi (2012) found that government action can lower the risk premium if agents believe it promotes an improvement in the economy. On the other hand, such an action carries uncertainty about its effectiveness. It seems, therefore, that an anticipated tax increase can be considered "good", as opposed to a sudden tax increase. In the latter case, companies may simply have less time to adjust to the new tax environment, as do households.

7. Robustness check

As the results in this article are very close to Radwański (2019), obtained with a different method, they can be considered robust. However, since any empirical model is subject to assumptions, it is always worth analysing the sensitivity of results. In this case the main assumption was taken on stationarity of interest rate. In the data sample the ADF test suggested a different conclusion under assumption of the trend in the data.[25] The VAR model build without taking first the differences[26] in the WIBOR rate provided similar results, implying that assumption on Wibor1M nonstationary does not affect the results (Figure 5).

8. Summary

This article analyses the response of the risk premium on the Warsaw Stock Exchange to changes in taxes using a VAR model identified which sign restrictions. The results obtained confirm the conclusions of Radwański (2019) about the increase in the risk premium following an increase in taxes. This corresponds to the economic theory that a decrease in income and consumption reduces investors' demands on risky assets. The results also indicate the "resilience" of GDP to tax increases. Although the GDP dynamic decreases after a tax hike, it quite quickly returns above the baseline scenario to stabilize in later periods. In this situation, the increase in stock market risk premium should be linked to an increase in risk aversion, while the expected situation of companies after the tax hike may be unchanged.

A slightly different conclusion is provided by a simulation in which a tax hike is announced a year in advance. GDP growth declines below the baseline scenario, accompanied by an initial decline in the risk premium. This result can be explained by different expectations about the ultimate results of the tax increase. It seems that an anticipated tax increase can be considered "good", as opposed to a sudden tax increase. In the latter case, companies may simply have less time to adjust to the new tax environment, as do households.

Taken together, these results show that waiting for a tax hike can have even more adverse effects on the economy than the tax hike itself. From the point of view of economic policy, such a result implies that tax increases should be implemented quickly enough not to keep economic agents in a long period of uncertainty. In addition, the results support the pursuit of responsible fiscal policy, so that a deficit that is too high does not trigger expectations of tax increases in the future.

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[25] The P-value for AFD test without trend and with trend in the data amounted to 6.8% and 15.6% respectively.

[26] VAR with 3 lags – the lowest lag order for which residuals were not autocorrelated (up to 4 lags).

Finally, the analysis also indicated the very high usefulness of sign restrictions as tools in the identification of tax shocks. Despite the simplicity of the method used, the results obtained in this article turned out to be very similar to those obtained by Radwański (2019) using a narrative variable. At the same time, sign restrictions is a much simpler method to use, which does not require time--consuming and error-prone construction of a narrative variable. The effectiveness of this method in identifying fiscal shocks is also indicated by a comparison of the results of simulations of a surprise shock and a shock announced a year earlier. In the first case, the response functions turned out to have a much larger amplitude, which confirms that the method used is an effective response to the problem of predictability of fiscal policy.

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Appendix

Table 1
Parameters of prediction equation

	OLS		BOOTSTRAP	
	PC1	**PC9**	**PC1**	**PC9**
Parameter	-0.2823	1.6926	-0.2133	1.1470
p-value	3.2%	0.0%	5.6%	0.0%

Source: own calculations.

Table 2
Cointegration tests between model variables depending on the number of lags and assumptions about trend and free expression

Lag number	**Data trend**	**None**	**None**	**Linear**	**Linear**	**Quadratic**
	test type	no intercept	intercept	intercept	intercept	intercept
		no trend	no trend	no trend	trend	trend
1	Trace	3	2	2	2	2
2	Trace	2	2	2	2	2
3	Trace	3	4	3	3	3
4	Trace	3	4	4	4	5

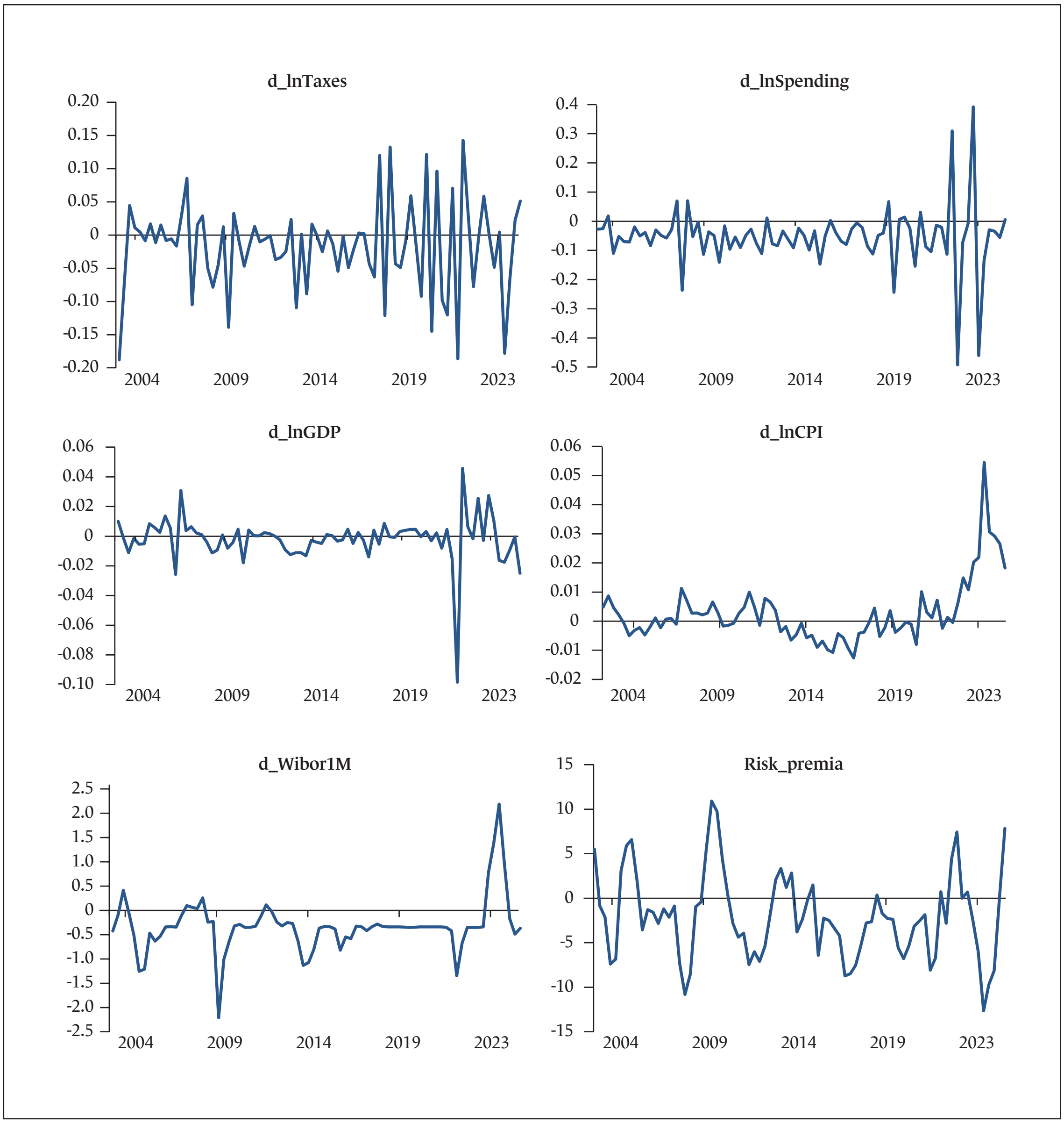
Source: own calculations.

Table 3
Restrictions on the sign adopted in different variants of the simulation

	Tax revenues dynamics	**Gov. spending dynamics**	**GDP dynamics**	**Consumer prices dynamics**	**Change in interest rate**	**Risk premia**
Sudden shock to taxes	+ (1–4)		– (1–1)			
Anticipated growth in taxes	+ (5–9)		– (1–1)			

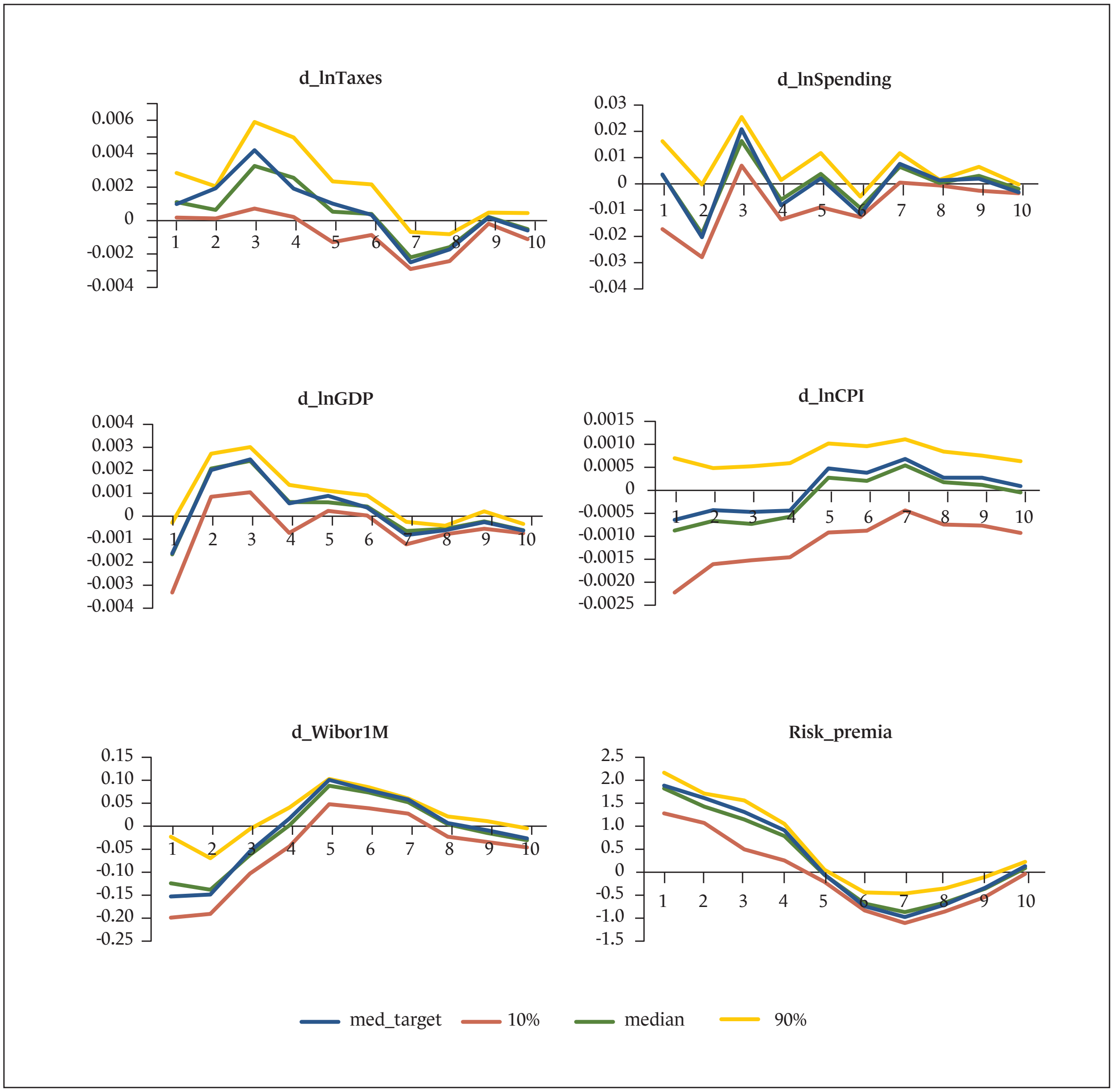
Values in parentheses correspond to quarters with restrictions.
Source: own calculations.

Figure 1
Variables included in the VAR model



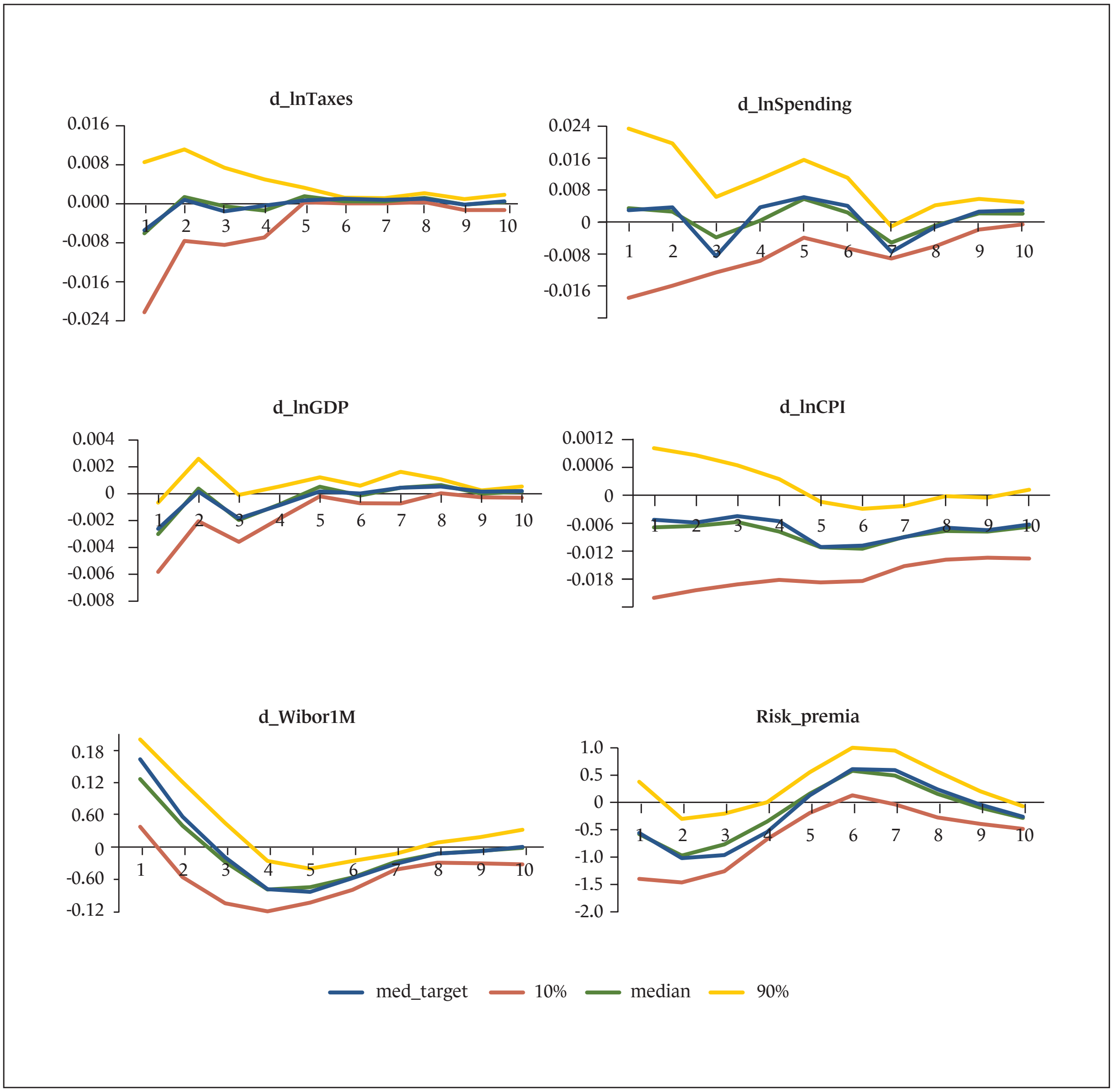
Source: own calculations.

Figure 2
Impulse responses to a sudden growth in taxes



Source: own calculations.

Figure 3
Impulse responses to an anticipated growth in taxes



Source: own calculations.

Figure 4
Variables used for principal components analysis

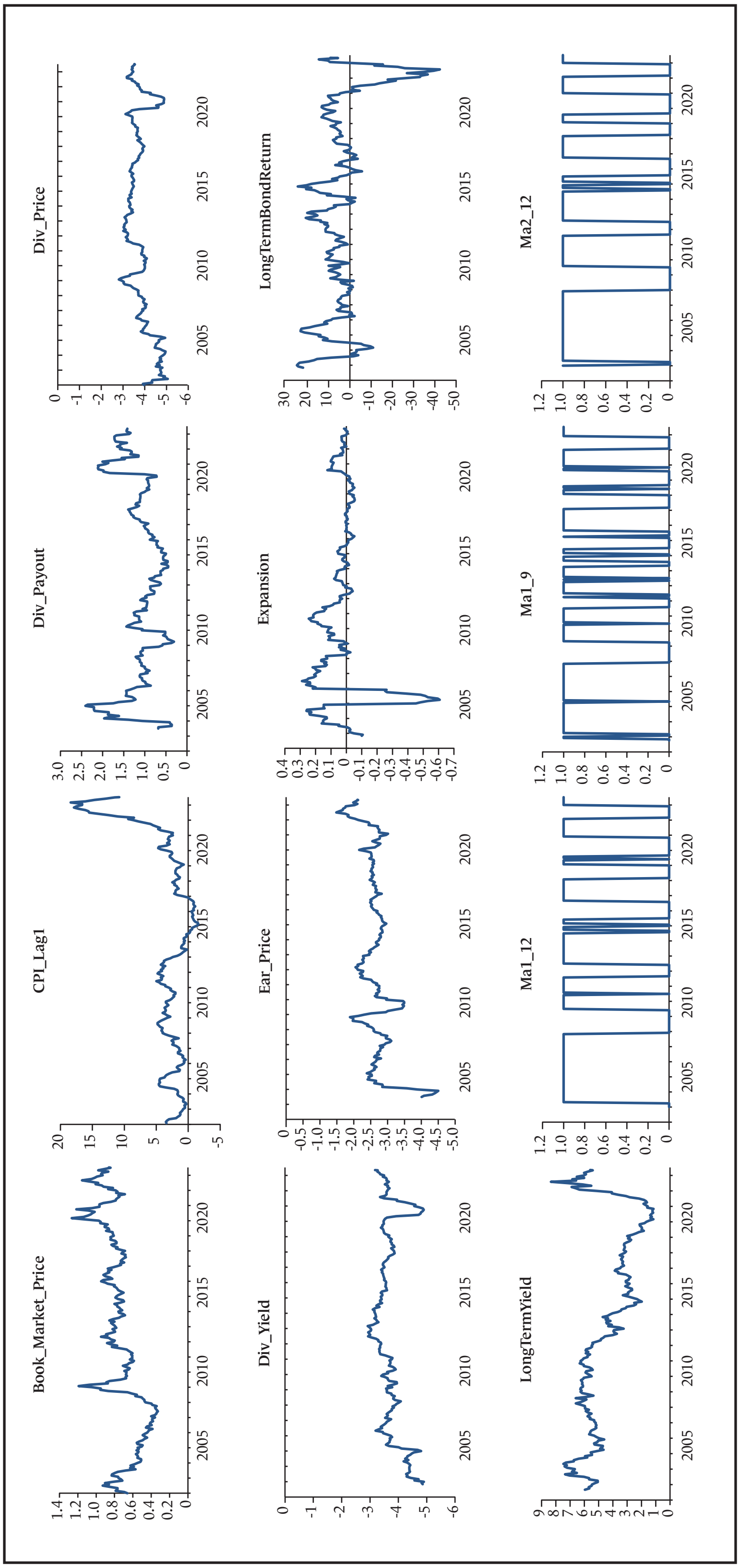


Figure 4, cont'd

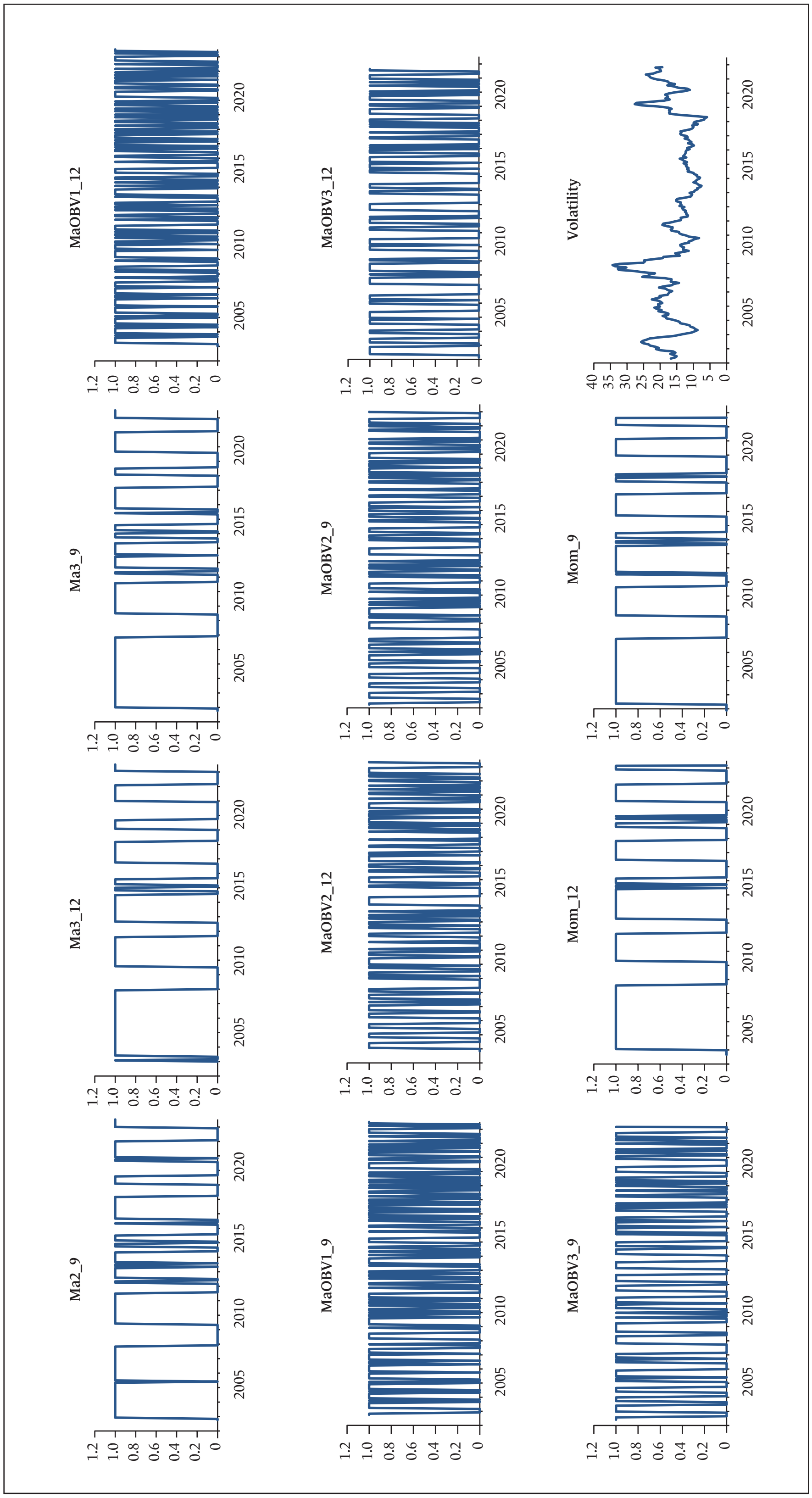
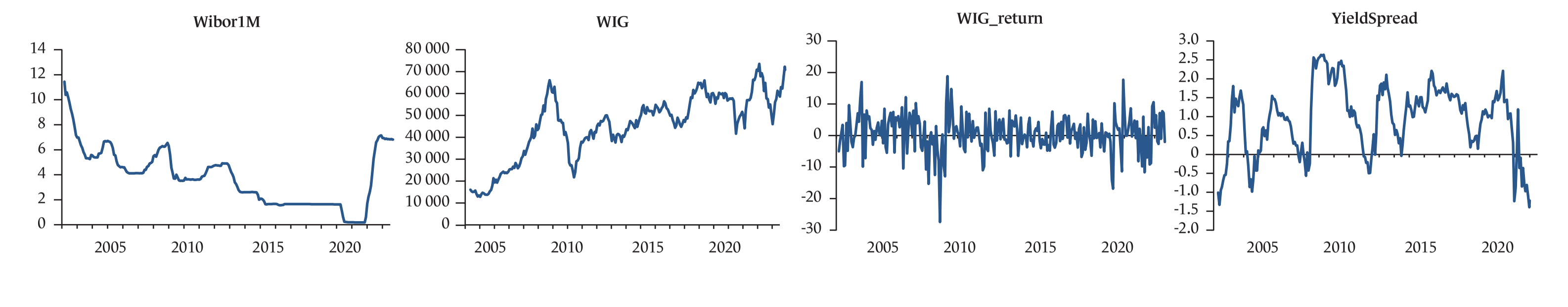


Figure 4, cont'd

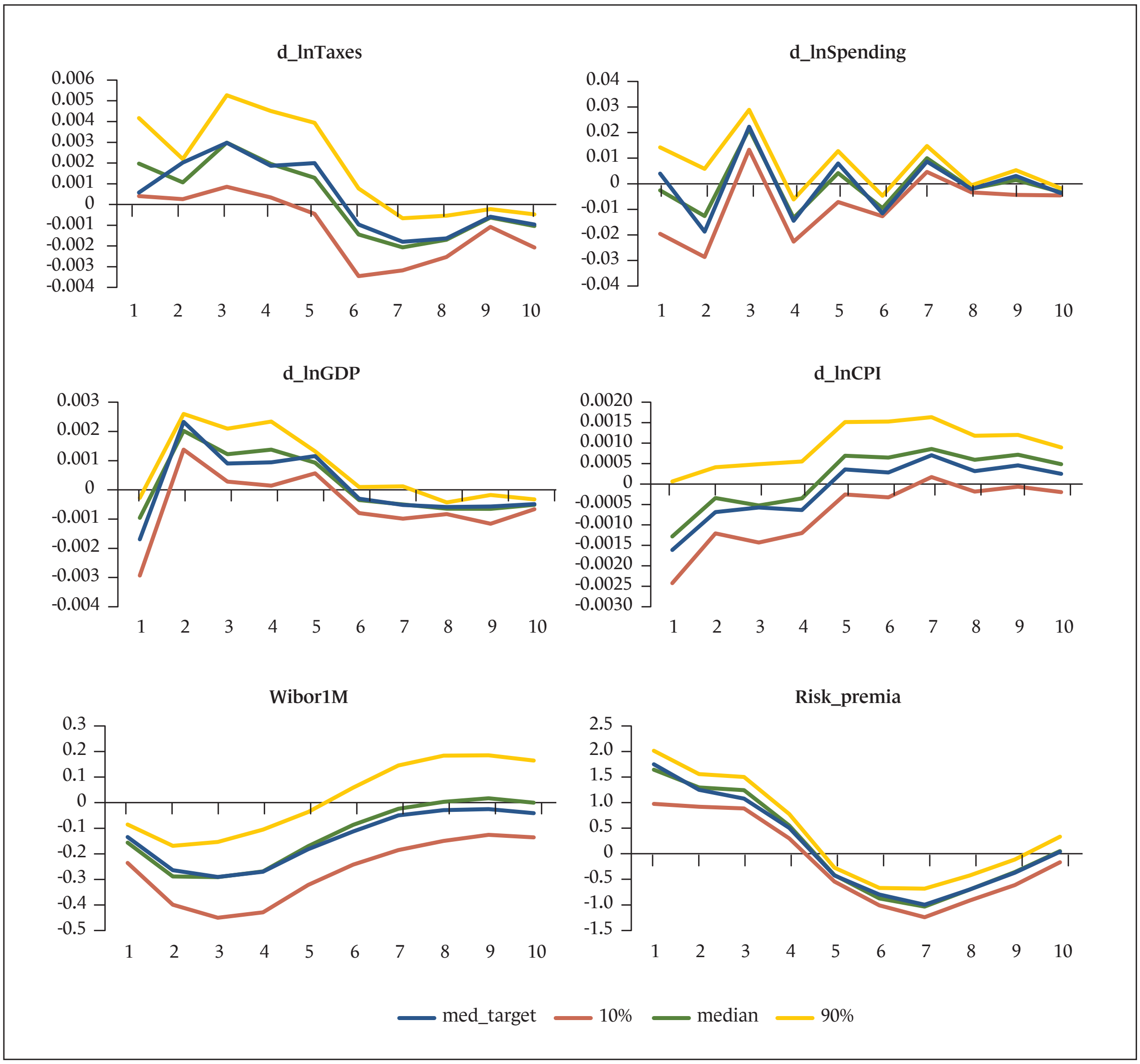


Book_Market_Price – book value of companies included in the WIG index divided by the index level;
CPI_lag1 – annual consumer price dynamics lagged 1 period;
Div_payout – logarithm of the sum of dividends paid by WIG companies over the last 12 months minus the logarithm of the sum of net profits during the period;
Div_Price – logarithm of the total dividends paid by WIG companies over the past 12 months minus the logarithm of the index value at the end of the period;
Div_Yield – logarithm of the sum of dividends paid by WIG companies in the last 12 months minus the logarithm of the index value at the beginning of the period;
Ear_Price – logarithm of the sum of net earnings attributable to shares of all WIG index companies over the last 12 months minus the logarithm of the index value at the end of the period;
Expansion – the net value of new stock issues over 12 months divided by the total capitalization of the companies constituting the index at the end of the period; the value of new issues was calculated as the change in the total capitalization of the index less the increase in capitalization resulting from the change in market prices;
LongTermBondReturn – total annual return on the 10-year benchmark bond;
LongTermYield – yield on the 10-year government benchmark bond;
Volatility – the average of the last 12 monthly percentage returns of the index expressed in absolute terms and annualized;
Wibor1M – monthly Wibor rate;
WIG – Warsaw stock index;
WIG_return – monthly return on the WIG index;
YieldSpread – difference between the yield on the 10-year benchmark bond and the monthly Wibor;
MAX_Y – signal derived from the comparison of X and Y periodic average;
Mom_X – signal derived from market momentum for X periods;
MaOBVX_Y – signal derived from the comparison of on balance volume for X and Y periods.

Source: own calculations with monthly closing prices or daily closing prices for averages.

Figure 5

Impulse responses to a sudden growth in taxes – Wibor1M assumed stationary



Source: own calculations.

Wpływ zmian podatków na premię za ryzyko indeksu WIG

Streszczenie

Premia za ryzyko, rozumiana jako dodatkowa oczekiwana stopa zwrotu, której inwestor może oczekiwać za podjęcie ryzyka, jest jednym z najważniejszych parametrów potrzebnych do oceny atrakcyjności inwestycji. Krótko- i średnioterminowe wahania premii za ryzyko są zwykle związane ze zmianami dochodów i konsumpcji lub czynnikami behawioralnymi. Można zatem przypuszczać, że czynniki, które mogą wpływać na te zmienne, mogą również wpływać na premię za ryzyko. Jednym z najważniejszych szoków, które mogą oddziaływać na gospodarkę, jest zmiana podatków. Ma ona wpływ zarówno na dochód do dyspozycji gospodarstw domowych, jak i na oczekiwaną stopę zwrotu z inwestycji po opodatkowaniu.

Głównym celem artykułu jest wypełnienie luki w literaturze i empiryczna analiza wpływu zmian podatkowych na premię za ryzyko indeksu WIG. W tym celu wykorzystano model autoregresji wektorowej, w którym szoki podatkowe zostały zidentyfikowane za pomocą restrykcji na znak. Dodatkowym celem badania jest sprawdzenie, czy identyfikacja szoków podatkowych tą metodą może być alternatywą dla bardziej złożonych metod, opartych na zmiennych narracyjnych.

Oszacowane w artykule wyniki wskazują na silny wzrost premii za ryzyko po podwyżce stawek podatkowych, czemu towarzyszy spadek tempa wzrostu PKB. Następnie premia stopniowo spada w kierunku scenariusza bazowego, czemu towarzyszy szybka poprawa dynamiki PKB, która wzrasta nawet powyżej scenariusza bazowego. Wyniki te są zbliżone do wyników Radwańskiego (2019), co wskazuje, że identyfikacja za pomocą restrykcji na znak jest skuteczną alternatywą dla zmiennych narracyjnych. Jednocześnie metoda ta oferuje większą elastyczność i nie pociąga za sobą ryzyka błędów pomiaru często występujących w narracyjnych szeregach czasowych.

Nieco inne wnioski płyną z symulacji, w której podwyżka podatków zostaje ogłoszona z rocznym wyprzedzeniem. Wzrost PKB spada poniżej scenariusza bazowego, czemu towarzyszy początkowy spadek premii za ryzyko. Wynik ten można wyjaśnić różnymi oczekiwaniami odnośnie do ostatecznych rezultatów podwyżki podatków. Jest to zgodne z literaturą przedmiotu, która stwierdza, że działania w obszarze polityki fiskalnej mogą obniżyć premię za ryzyko, jeśli agenci uważają, że będą one zwiększać siłę nabywczą gospodarstw domowych np. stymulując wzrost PKB. Z drugiej strony istnieje niepewność co do skuteczności tych działań. Wydaje się zatem, że przewidywana podwyżka podatków może być uznana za „dobrą", w przeciwieństwie do nagłej podwyżki podatków. W tym drugim przypadku firmy mogą mieć po prostu mniej czasu na dostosowanie się do nowego otoczenia podatkowego, podobnie jak gospodarstwa domowe.

Słowa kluczowe: polityka fiskalna, premia za ryzyko na rynku akcji, model VAR, restrykcje na znak, finanse behawioralne