Dear Committee members, dear colleagues. My name is Artur Zmanovskii and today I’m presenting my master dissertation, where I make a humble attempt to estimate exchange rate pass-through to inflation for Russia.

(slide 2 — Overview)

First, I’ll provide you a small justification of my work’s importance, then I’ll do a little bit retrospective, guide you through all the tricks involved in estimation, that’s the most time-consuming, and, finally, reveal my results.

(slide 3 — Introduction)

To start with, I’d like to pay attention to why the topic is important. Russia, assuming it’s a small open economy, is exposed to exchange rate fluctuations. Hence, there is a correspondence of domestic price level and exchange rate movements. It is natural to assume that there is no one-to-one correspondence, or, in other words, complete pass-through, as firms are competitive, and they may adjust their mark-up in order to soften exchange rate fluctuations. Moreover, Russia, as a commodity exporter, enormously depends on oil price shocks, which is interesting to study.

(slide 4 — Literature Review)

So, what the literature tells us? Fairly few things. Overwhelming majority of works estimate unconditional pass-through value, which is not informative and, well, very crumpled. Most papers use consumer price index as an inflation variable, and they split in a half considering underlying foreign currency. The most recent work here, dated 2019, makes a rather good attempt to estimate shock-dependent exchange rate pass-through based on DSGE model, and, well, there are no other studies estimating shock-dependent pass-through. Meanwhile, papers for Euro area widely use structural vector autoregressions to determine it, so, the purpose of my work is to fill this gap in the literature and apply modern econometric method to estimate pass-through values.

(slide 5 — Methods: unconditional ERPT)

Switching to methods, first, I’d like to explain the basic and the most widely used method in order to give to audience a better understanding of what’s going on. In a very basic scenario, to estimate unconditional exchange rate pass-through to price level, you need to estimate a simple dynamic model with inflation as dependent variable and exchange rate aggregate together with control variables as regressors. Summing up coefficients of exchange rate, you get unconditional pass-through estimate. But the things are not so straightforward — this value is shock-independent and quite uninformative in terms of shock decomposition, so policy-making based on this number, indeed, is not prudent.

(slide 6 — Methods: PERR)

Then, we have to apply something more cumbersome — vector autoregressions are all about shocks, so they may tackle a problem. Going forward, in this work I estimate Bayesian VAR with five variables displayed on the slide. For VAR, shock-dependent exchange rate pass-through, or, for disambiguation, price-to-exchange rate ratio, is just a ratio of sums of impulse response functions for price and exchange rate of a particular shock.

But, as usual, things are not that easy, since after estimation you’ve got statistical shocks, not structural ones, since covariance matrix is not diagonal, and shocks are connected. The key difference is that you hardly can interpret statistical shocks, so, we have to appeal to full form of vector autoregression.

(slide 7 — Methods: SVAR)

And here it is! The crucial difference is that there is a matrix of contemporaneous effects, A-zero, in the left hand side, and the whole business is, in some sort, in recovering it from the model. Full form already contains structural shocks with identity covariance matrix, that are interpretable and, well, that are the main point of estimation of structural vector autoregression. Since reduced-form VAR does not contain A-zero, we assume the whole equation is already multiplied by its inverse, so coefficients in reduced form are just products of A-zero and respective A-positive. Talking about covariance matrix, we can notice that statistical shocks are just product of A-zero-inversed and vector of structural innovations. Anyway, expectation of this vector is zero-vector, but the idea is hidden in covariance matrix. If we take a matrix root of it, we’ll recover A-zero-inverse! Again, there is a trap: matrix square root may be not unique. The most common matrix root is Cholesky decomposition given in the slide, but it assumes a recursive relation of shocks and variables, so, for example, lower Cholesky decomposition assumes that the first shock gives innovations to all the variables in the model, while the last shock changes only the last variable contemporaneously, and vice versa for upper decomposition.

(slide 8 — Methods: Zero and sign restrictions)

Alright, it’s bad. But there is a stochastic solution — since you taking a square root from covariance matrix, multiplying it by some orthonormal matrix, which conjugate product gives an identity matrix, is harmless — it’s just like multiplication of value by its inverse. Generating lots of such orthonormal matrices and checking the signs of impulse-response functions for each matrix yield an identified model! The seminal work of people from FED, Arias, Rubio-Ramirez and Waggoner, explains how to do that in this algorithm. Purely technical limitation is that there should be less zero restrictions than a shock’s order usually can be mitigated by reordering variables. From here I stop going deeper into technical details and shift to my particular model.

(slide 9 — Data: Variables)

I use five quarterly time series from 2005 to 2020, 63 observations in total. Interest rate is the only variable that is not in growth rates, it’s quite natural in macro research. I associate spot Brent oil price with global economy shocks, Moscow interbank average credit rate with monetary policy, nominal effective exchange rate with exogenous exchange rate shocks and real gross domestic product with domestic supply fluctuations. There are two variables for price level — full and core CPI compositions. For each of them, I estimate separated Bayesian VAR. These are associated with domestic demand. Core CPI does not include prices for goods and services, which pricing is regulated by authorities, and exposed to seasonality. For example, fuel and vegetables are out of the core list.

(slide 10 — Model: Identification scheme)

I check five hundred thousand models in total — for each of five hundred draws I generate a thousand random matrices and check for signs. The restriction matrix displayed here is inspired by the remarkable work of Forbes and co-authors for UK, sanity check is done basing on medium-scale DSGE model for Russia.

I agnostically assume that a positive demand shock heats prices and output, while monetary authority rises interest rate to counterbalance it. A positive supply shock drops prices since there are more goods and services. Monetary policy tightening, associated with interest rate rise, cools down economy. Exogenous exchange rate shock, which may occur due to changes of agents’ risk-aversion, definitely rises prices and interest rate. Finally, global economy shock, associated with oil prices, has ambiguous influence on the Russian economy, but certainly cools down exchange rate. Finally, no domestic shocks change oil price due to assumption of small open economy.

(slide 11 — Results: PERR)

So, here it is, estimated shock-dependent exchange rate pass-through values for both full and core CPI in short- and long-run. Focusing more on full CPI, I can say that global economy shock pass-through is quite tiny in the long-run together with the value for demand shock. This may be a consequence of including price-regulated goods into full CPI composition, just look at the respective values of core CPI. Moreover, all PERR values for core CPI are higher in absolute values. It means that overall pass-through to core CPI is higher than to full composition.

Another point is that PERR is faster for core CPI — in short-run all the values, except for supply shock, are larger. Finally, I have to notice that the highest pass-through value is for exogenous exchange rate shock, the nature of which I’ll reveal on the next slide.

(slide 12 — Results: HD)

This slide is to show historical decomposition of full CPI growth rate from 2005 to 2020. Bars of different colors show value and direction of relative shock innovation to the inflation aggregate. As the agenda today is quite a lot about pandemic, let’s look at the last four periods closer. I find that COVID-19 crisis was mainly driven by supply and oil shocks in Russia. In the same time, rapid price level acceleration in fall of 2020 can be associated with supply, monetary and exchange rate shock. The behavior of exchange rate shock is interesting, and it’s linked to political events, like waves of sanctions in the end of 2014, after March of 2017 and August 2020. A quite counterintuitive decomposition is for monetary shock — in general, Bank of Russia was gradually decreasing interest rate for the last five years, but the effect to inflation is negative. This is not a price puzzle that is usually found for vector autoregressions, where IRF of monetary shock to inflation is positive, since IRF in my model is negative by construction. It might be that there was a cooldown from dramatic increase of the rate in the end of 2014, so the agents were recovering supply-demand equilibrium. I won’t be talking about core CPI decomposition now, since I am limited in time, but it’s in Annex.

(slide 13 — Conclusion)

To conclude with, I’d like to describe in a nutshell what I did — I estimated two Bayesian vector autoregressions with essential macro variables, then applied a sophisticated identification algorithm and calculated ratios of IRF’s sums. These values are useful, since they aid to understand more deeply how the shocks affect Russian price stability. I find my results close to the work of Khotulev, who gets his values using DSGE model, and I notice an obvious fact that pass-through in Russia is higher than in Euro zone. Core CPI is more sensitive to exchange rate fluctuations under different shocks, and pandemic crisis is rather driven by global and supply shocks.

There are a few policy implications. First, when there are political tensions, a more aggressive exchange rate management may be beneficial. I understand that in current framework the central bank is quite tied, but prudent reserves accumulation and use may ease inflation growth. Second, monetary policy also has a huge pass-through, but tightening monetary policy may yield benefits only in short-run, while in the long-run there would be lack of domestic supply, which could heat up prices.