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REPUBLIC OF LITHUANIA

SELECTED ISSUES

July 2019

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July 12, 2019

Approved By
European Department

Prepared by Kanghoon Keah and Vina Nguyen

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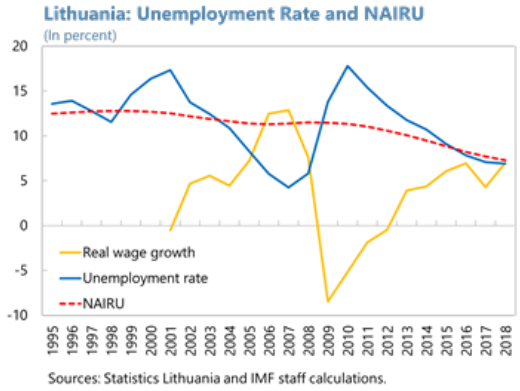
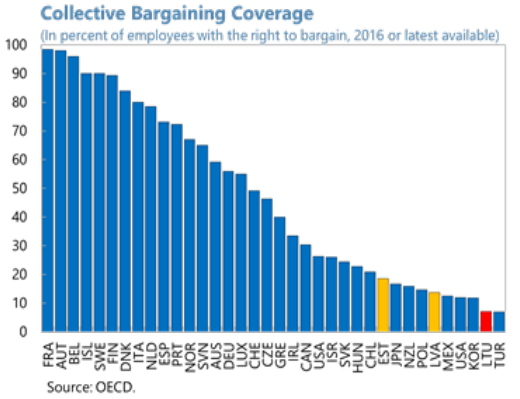
SKILLS MISMATCH AND ACTIVE LABOR MARKET POLICY IN LITHUANIA[1]

A. Labor Market in Lithuania



1. Lithuania's labor market is characterized by a large flexibility, but persistent structural issues. Contrary to other European economies, wages in Lithuania are very sensitive to unemployment and, therefore, an increase in unemployment quickly leads to a reduction in wage growth. During the crisis, real wage growth dropped to -9 percent in 2009 from the pre-crisis peak of 14 percent in 2007.

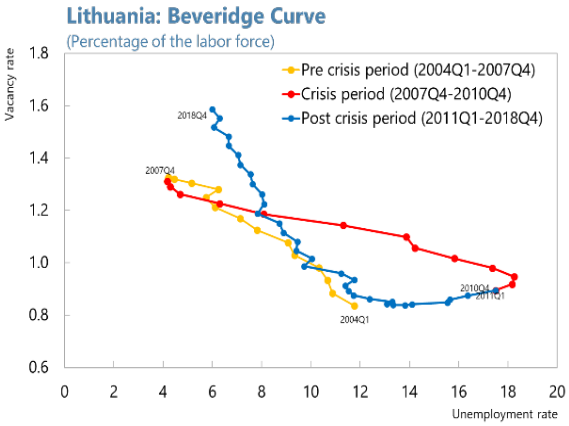


2. Wage flexibility is underpinned by one of the lowest densities of trade union and employer organization and the rare occurrence of collective bargaining. Thus, wage setting largely happens at the firm level. Real wages and productivity have been traditionally closely linked and temporary deviations have been self-correcting. However, deviations at the sectoral level can be persistent although in the all-important manufacturing sector, wage growth has remained well below productivity growth (IMF Country Report No. 5/139).

3. In contrast, structural unemployment has been traditionally high, although it appears to be gradually falling. Large structural unemployment can have a significant long-term impact on potential growth and, therefore, on employment (IMF Country Report No. 18/185). The rapid decline in the unemployment rate since the crisis occurred at a time of increasing participation rates and has been below pre-crisis estimates of the non-accelerating inflation rate of unemployment (NAIRU) for a few years without inflationary pressures emerging. This suggests that the NAIRU has been gradually decreasing to around 7 percent, as estimated in a multivariate factor (MVF) model. Regardless of the current level of the NAIRU, it seems clear that the current level of unemployment in Lithuania is largely of a structural nature.

[1] Prepared by Kanghoon Keah.

4. In addition, the Beveridge curve shifted outward during the crisis, but the quick recovery appears to have shifted the curve back in, at least partially. It also suggests that the efficiency of the labor market deteriorated during the crisis, but has only partially recovered since.

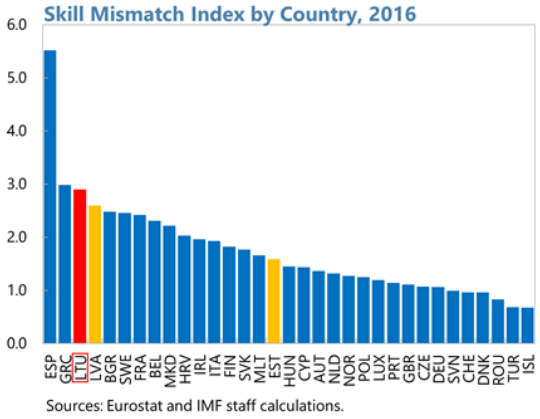


Sources: Statistics Lithuania; Eurostat; and Haver Analytics.

5. Although several factors explain structural unemployment, this paper will focus on labor market mismatches and policies to address them. This paper analyzes the evolution of skill mismatches in Lithuania since the crisis and presents international experience on active labor market policies (ALMPs) that have been used to combat them.

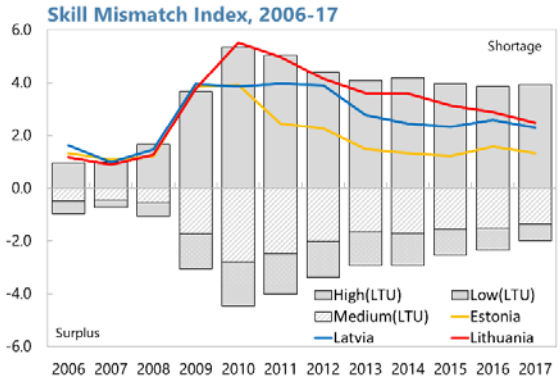
B. Skills Mismatch in Lithuania

- *Lithuania has one of the highest skill mismatches in Europe. Aggregate measures of skill mismatches in Lithuania increased sharply during the crisis, but only partially recovered since. Looking at the individual job level, mismatches in Lithuania are in line with other OECD countries.*
- *Lithuania suffers from relative labor shortage for high-skilled workers and surplus of low- and medium-skilled workers. Thus, there are labor shortages in skill-intensive sectors (e.g., ICT and finance), and excess labor in less-skill-intensive sectors (e.g., construction and trade).*



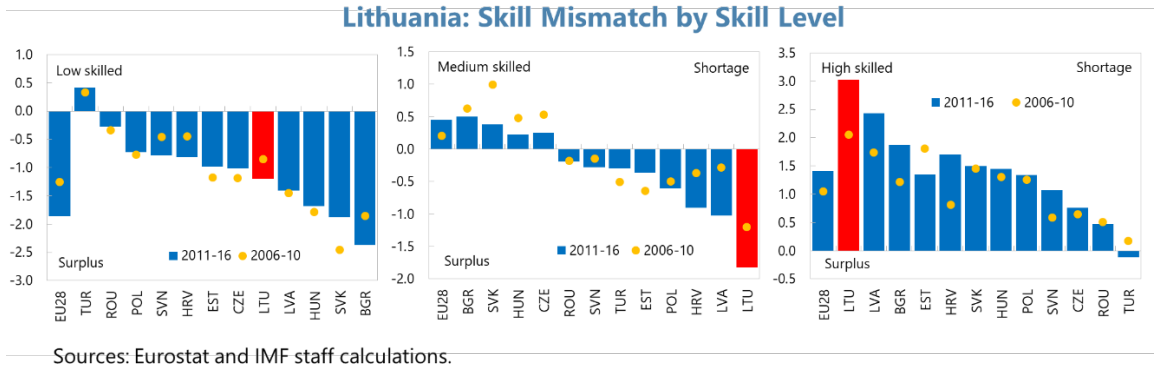
Sources: Eurostat and IMF staff calculations.

6. Lithuania has shown a sharp rise in skills mismatch for the country as a whole in the aftermath of the crisis. The skills mismatch index used here follows the framework in Estevao and Tsounta (2011), and measures the gap between labor supply and demand by the level of education attainment for the economy as a whole (Box 1). Under this index, Lithuania has one of the highest skills mismatches in Europe. Furthermore, it increased sharply during the crisis driven by the increases in relative shortage of high-skilled workers and/or relative surplus of low- and medium-skilled workers. While partially recovering since, it has remained significantly above pre-crisis levels in line with Latvia. Estonia on the other hand has recovered to levels comparable to pre-crisis. The impact of the crisis has, therefore, been large and persistent despite the flexibility of the labor market to cyclical fluctuations, highlighting once again the structural nature of current unemployment.



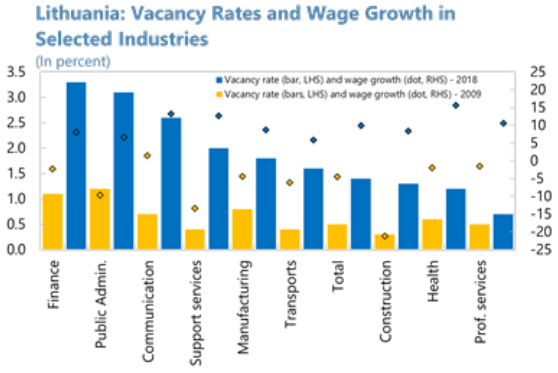
Sources: Eurostat; and IMF staff calculations.

7. Lithuania suffers from labor shortage of high-skilled workers and oversupply of medium- and low-skilled workers. Further, the imbalances across skills level have increased since the crisis. The relative skill mismatch is particularly severe in Lithuania compared to other European economies and seems to reflect the legacy of the pre-crisis years where the boom in low-skills sectors, notably construction, has resulted in an oversupply of low-skilled labor. Shortcomings in the education system also play a role in these dynamics. In particular, there is a gap between educational outcomes and the skills demanded by the labor market. Finding workers with the right skills appears to be a significant constraint for over 40 percent of firms.[2] High emigration and certain restrictions on non-EU workers, as well as limited participation in life-long learning, also explain the lack of suitable labor in Lithuania (OECD, 2018a).



Sources: Eurostat and IMF staff calculations.

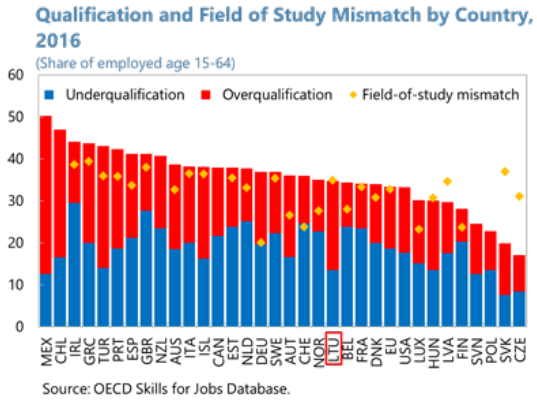
8. Vacancy rates and wage growth by sectors also suggest an excess supply of lower-skilled workers and shortage of high-skilled ones. Skill-intensive sectors, such as finance and communication, are high in both wage growth and vacancy rates, suggesting shortages due to the insufficient supply of workers with the right skills. On the contrary, less-skill-intensive sectors, such as transports and construction, are high in wage growth, but have low job vacancy rates, implying there is no shortage of workers in these sectors. Low job vacancy rates even at times of high employment growth in these sectors suggest that there are no labor shortages whereas high wage growth is an indication of the tightness of the labor market operating below NAIRU. Similarly, according to the EU, Lithuania's high skill needs ("shortage occupations") lie in ICT professionals, engineers, etc., while street salesperson, childcare workers, teachers' aides, machine operators and transport clerk are in excess supply, "surplus occupations" (EC, 2017).



Sources: Lithuania Statistics and Haver Analytics.

[2] According to European Investment Bank (EIB Investment Survey, 2015), 40 percent of Lithuanian firms point out "availability of staff with the right skills" as major obstacles to investment, following "business regulations and taxation".

9. By focusing on labor mismatches at the individual job level rather than at the aggregate, Lithuania ranks better, but remains a low-skill-oriented economy. The OECD's Skills for Jobs Database presents information on skills shortage and mismatch in field-of-study and qualification (Box 2). According to these indicators, the field-of-study mismatch is slightly higher, at 35 percent, in Lithuania compared to the EU average of 32 percent. Interestingly, Lithuania turns out to be high in overqualification while low in underqualification relative to other EU countries (OECD, 2017). In addition, Lithuania has relatively low knowledge and ability needs, as technology-related skill needs are relatively small, while low-technology skills are more in demand.



Box 1. Aggregate Skills Mismatch Index[1]

- Skills mismatch occurs when skills supplied by a worker differ from the ones demanded by his job. Accordingly, a skills mismatch index can be constructed reflecting the difference between the share of employed (skills demanded) and labor force (skills supplied) at each skill level.

- The skill level is measured by data on education attainment from European Labor Force Survey (EULFS), and categorized as low skilled (less than primary, primary and lower secondary education), medium-skilled (upper secondary and post-secondary non-tertiary education), and high-skilled (tertiary education). To account for the differences in the education quality overtime, tertiary education is adjusted for the quality of education based on data from the World Economic Forum.

- Following the framework presented in Estevao and Tsounta (2011), the aggregate skills mismatch index at time *t* can be constructed as:

$$\text{Aggregate Skills Mismatch}_t = \sqrt{\sum_{j=1}^{3} \left(S_{j,t} - M_{j,t}\right)^2}$$

where *j* is the skill level; $S_{j,t}$ is the percentage of the population with skill level *j* at time *t* (skills supplied) and $M_{j,t}$ is the percentage of employees with skill level *j* at time *t* (skills demanded).

1/ The construction of the aggregate skill mismatch index used in this paper benefits from the IMF Country Report No. 18/242.

Box 2. OECD's Skills for Jobs Indicators[1]

- The OECD Skills for Jobs Database presents two sets of indicators: the skill needs indicators, including shortage/surplus of skills and occupations; and mismatch indicators, including qualification mismatch and field-of-study mismatch.
- The qualification mismatch index calculates the share of workers in each economy/occupation that are under- or over-qualified to perform a certain job. This is done by computing the modal educational attainment level for each occupation in each country and point in time and use this as a benchmark to measure whether individual worker's qualifications match the 'normal' educational requirement of the occupation. Thus, over-qualification (under-qualification) depicts a situation for which the highest level of education achieved by an individual worker in an occupation is above (below) the modal level for all workers in that occupation.
- Field-of-study mismatch is distinct from qualification or skills mismatch as a worker may be well matched to his/her job in terms of the key information-processing skills possessed (skills match) or educational attainment (qualification match), but not by the type of education and knowledge received during his/her official training and education.

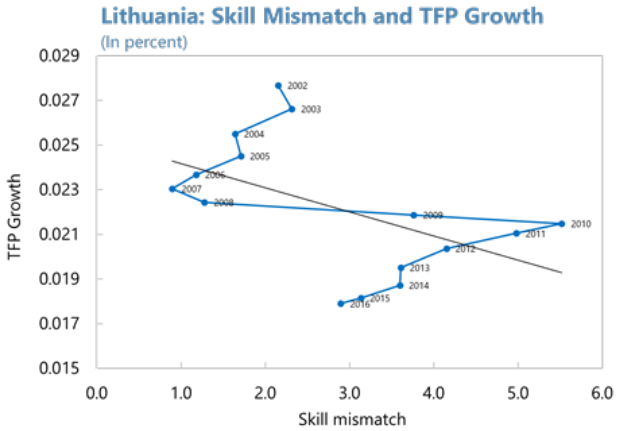
1/ OECD (2017), Getting Skills Right: Skills for Jobs Indicators.

Impacts of Skills Mismatch on Productivity

10. Skill mismatch negatively affects productivity via misallocation of the workforce and insufficient accumulation of firm-specific knowledge. Individual workers are also affected by skills mismatch through a higher risk of unemployment, lower wages, lower job satisfaction and poor career prospects. A high proportion of Lithuanian firms cite an inadequately educated workforce as a significant obstacle to their operations compared with other Central and Eastern European countries in 2013 (OECD, 2016b).

11. There are several channels through which skills mismatch affects productivity. Compared to well-matched workers, over-qualified workers tend to participate less in training, which hinders accumulation of firm-specific knowledge (Verhaest and Omey, 2006). Skill shortages negatively affect technology adoption and investments in tangible and intangible assets (Forth and Mason, 2006). Under-education can be detrimental to firm productivity as shown by Kampelmann and Rycx (2012) using employer-employee panel data for Belgium. A negative impact of over-qualification on productivity happens through a less efficient allocation of resources, while that between under-qualification and productivity through lower allocative efficiency and within-firm productivity (McGowan and Andrews, 2015).

12. Empirical studies found that countries with high skills mismatch tend to have lower productivity. A study with panel data for 26 European countries including Lithuania over 1995–2016, found that skills mismatch index had a negative and statistically significant impact on total factor productivity (TFP) and labor productivity (IMF Country Report No. 18/242). In line with McGowan and Andrews (2015), given that the negative association remains statistically significant even after controlling for the level of human capital, the study also found that the misallocation that generates skills mismatches played an important role in reducing productivity gains from human capital. Lithuania also follows this general pattern with an increase in skill mismatches in the aftermath of the crisis associated with a significant decline in productivity as indicated by the scatter plot chart on skill mismatch index and TFP growth.



Source: IMF staff calculations.

C. Active Labor Market Policy in Lithuania

The Economics of Active Labor Market Policies

13. Active labor market policies (ALMPs) encompass government programs to increase the efficiency of the labor market.[3] There are different categories of ALMPs:

- *Job search assistance (JSA)*: includes job centers and labor exchanges that try to improve labor market matching by disseminating information on job vacancies, providing the unemployed with interview skills, or assisting in writing a curriculum vitae.
- *Vocational education and training (VET) schemes*: encompass classroom training, on-the-job training, vocational education and apprenticeships, and aim to help the unemployed improve their vocational skills and productivity, and hence increase their employability.
- *Employment subsidies*: encompass wage subsidies, hiring subsidies, business start-up subsidies, and in-work benefits to encourage workers' labor market attachment and firms' job creation.
- *Public works programs (PWP):* provide the temporarily unemployed with short-term employment.

JSA and VET address skills mismatch more directly, while employment subsidies and PWP are more supportive of employment.

14. A number of empirical studies established positive effects of ALMPs on employment. For example, using panel data for 15 industrial countries in the 1985–2000, Estevao (2003) estimated

[3] In contrast, passive labor market policies (PLMP) aim at providing income replacement during periods of unemployment or job search, which include unemployment insurance and early retirement for labor market reasons.

that a 1 percentage point increase in ALMP spending relative to GDP would increase the employment rate by 1.9 percentage points in the 1990s. More recently, the Bank of Lithuania (2016) simulated the effect of social policy proposals in Lithuania's New Social Model in 2015 on unemployment using an open economy vector autoregressive (VAR) model.[4] They assumed an increase in ALMP expenditure financed by imposing a 15 percent income tax on unemployment benefits and found a reduction of the unemployment rate as a result.

15. The effectiveness of ALMPs can vary according to the type and duration of the program, and the characteristics of the participants. Card et al. (2009, 2015) assessed the relative effectiveness across active labor market programs based on an extensive meta-analysis on 207 different empirical studies covering 857 programs in total. According to their study:

- In terms of *the type of program:* JSA programs have a relatively short-run impact on employment for disadvantaged participants, whereas job training programs tend to produce better outcomes for the long-term unemployed in the medium-run than the short-run.[5] Employment subsidies, particularly in the public sector, tend to have negligible or negative impacts at all time horizons.
- In terms of *the characteristics of the participant:* the impact of ALMPs vary across groups, with a larger impact on female workers and the long-term unemployed, while smaller impact on older and young workers.
- In terms of *the duration of the program:* on average, ALMPs have relatively small impact in the short run, while they have larger positive impact over the medium- and long-run.
- ALMPs are relatively more effective during periods of slow growth and higher unemployment.

16. However, ALMPs can also have negative unintended consequences. For example, support for unemployed and disabled workers may result in the substitution of existing employment and medium-skilled workers with job seekers and low-skilled workers ("substitution effect"). Low wage subsidies can also disincentivize unskilled workers from gaining further human capital ("skill acquisition effect"). ALMPs can even reduce job opportunities for participants by signaling their low productivity to employers ("stigmatizing").[6]

Active Labor Market Programs in Lithuania

- *ALMP expenditure in Lithuania is low in terms of investment and participation.*
- *ALMPs in Lithuania do not sufficiently reflect the labor market needs or cyclical conditions and rely largely on European funds. Spending is low in downturns and does not reflect increasing needs. Furthermore, training programs tend to focus on oversupplied skills.*

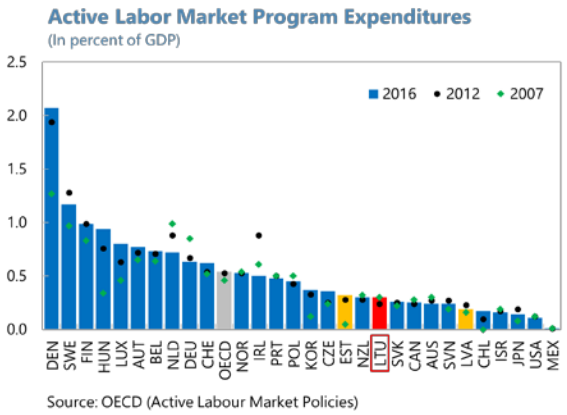
[4] They take into account four macroeconomic variables (real GDP, unemployment, the international trade over GDP, and the real effective exchange rate) and two institutional variables characterizing Lithuania's labor market (unemployment benefits and expenditure on ALMP over GDP).

[5] They define the 'short-run' as less than a year after the end of the program, the 'medium-run' as 1–2 years post program, and the 'long-run' as 2+ years.

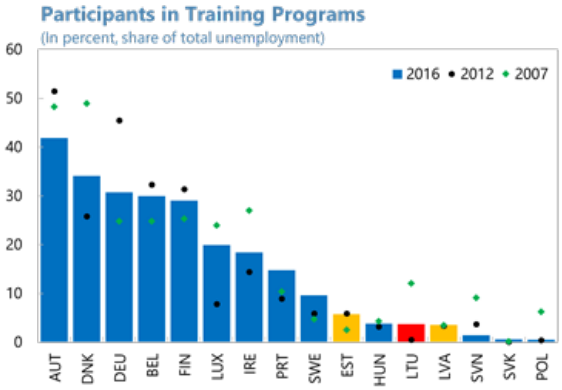
[6] See Brown and Koettl (2015) for more extensive and detailed discussion on side effects of ALMPs.

- *The cost-effectiveness of ALMPs could be enhanced by improving program design based on more systemic program evaluation.*

17. Investment and participation in ALMPs have remained relatively low in Lithuania. Spending on ALMPs is small at 0.3 percent of GDP in 2016 relative to OECD countries. Participation is also low with only 3.7 percent of the unemployed having participated in training programs in 2016.



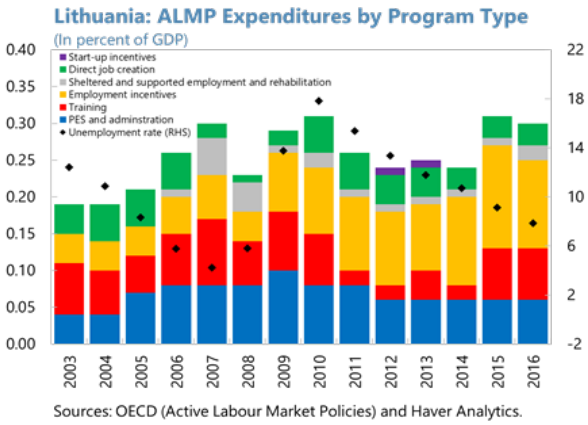
Source: OECD (Active Labour Market Policies)



Sources: OECD; Eurostat; Haver Analytics; and IMF staff calculations.

18. Spending on ALMPs has not been responsive to cyclical conditions and largely relies on European funds. ALMP spending relative to GDP has been fairly constant in Lithuania even in the aftermath of the global financial crisis when unemployment increased sharply. As a result, participation has been one of the lowest in Europe even after the global financial crisis. This is partly explained by the heavy reliance on external source of funding such as the European Social Fund (ESF)—almost two-thirds in 2015. The heavy dependence on EU funding, targeted at specific groups, has resulted in the unique situation of specifying beneficiary groups in the labor code: older workers, long-term unemployed, youth and the disabled. The new labor code, adopted in 2017, has now included unqualified persons to the list of potential beneficiaries.

19. Lithuania's ALMP measures consist of support for learning, mobility, assisted recruitment, and job creation.[7] The new labor code brought about changes in ALMP measures, which include promoting self-employment and internship, encouraging self-education and non-formal adult education, and providing support for mobility. The code abolished some of the programs, such as public works, job rotation and subsidies for individual activity according to business certificate. Employment subsidies have become the main ALMP measure. Unlike other types of program, which have maintained almost the same level of spending relative to GDP, expenditure on training has



Sources: OECD (Active Labour Market Policies) and Haver Analytics.

[7] Support for learning includes vocational training, recruiting under an apprenticeship contract, internship, and the recognition of non-formal and informal learning competences. Supported employment encompasses subsidized employment, supporting the acquisition of work skills, job rotation, and public works. Support for job creation includes subsidizing of job creation, implementation of local employment initiative projects, support for self-employment, and subsidy for individual activity according to business certificate.

fluctuated over time and increased recently after some years at very low levels during 2011–14. In addition, despite the introduction of the training voucher scheme in 2012, training programs are centered in curricula for low-skilled tasks, such as driving, construction, cooking and beauty services, which are already in excess supply of labor.

D. Policy Implication

20. Lithuania could take some actions to strengthen ALMPs to address skills mismatch:

- Spending on ALMPs should be increased with its funding being stabilized and secured with predictable and reliable public resources. In this regard, the program's scope and dimension should not be linked to European funds and its level should be responsive to cyclical developments in the labor market.

- Given the degree of skills upgrade needed in Lithuania, the recent increase in training spending is welcome and should continue. With 40 percent of the unemployed in 2015 having no professional qualification, the 3 percent of participation rate in training is inadequate. Training and re-training programs will directly address the issue of the over-supply of low-skilled workers for which there is no additional demand. Participation rules could be adapted to allow for long programs and those that require expensive equipments to increase the participation of low-skilled, older workers and workers in rural areas.

- The importance of employment subsidies in ALMPs should decrease. Currently, they are the main ALMP program in Lithuania. Given the challenges regarding the large stock of low-skill unemployment, and the lower effectiveness of employment subsidies discussed above, these should be concentrated on the most disadvantaged groups, those unlikely to find a job in their absence, and extra resources should be channeled towards training programs.

- The current voucher system to fund training program could be more effective by providing information on available programs for recipients to assess which training fits them best. Currently, there is no systemic rating system based on the labor market outcomes of previous participants.

- Comprehensive performance evaluation for ALMPs should be conducted on a regular basis and from a long-term perspective. Currently, programs are assessed quarterly by their impact on integration into the labor market, registration at the labor exchange, and direct benefits.[8] However, program evaluation should be strengthened to improve program design from a longer-term and broad-based perspectives.

[8] The evaluation in 2017 revealed that vocational training and support for the acquisition of work skills have a larger effect in the longer run (6+ month), while subsidized employment had relatively short duration and the impact disappeared over time. The impacts stabilized one year after the program participation.

References

Bank of Lithuania, 2016, "Impact of Labor Market Reforms on Lithuania's Economy," *Lithuanian Economic Review*, June 2016.

Brown, A., and J. Koettl, 2015, "Active Labor Market Programs—Employment Gain or Fiscal Drain?" *IZA Journal of Labor Economics*, Vol. 4, Issue. 12.

Card, D., J. Klube, and A. Weber, 2015, "What Works? A Meta-Analysis of Recent Active Labor Market Program Evaluations," Ruhr Economic Papers No. 572 (Essen: Rheinisch-Westfaelisches Institute fuer Writscharftsforschung).

Card, D., J. Klube, and A. Weber, 2009, "Active Labor Market Policy Evaluations: A Meta-Analysis," CESifo Working Paper, No. 2570 (Munich: Center for Economic Studies and Ifo Institute).

EC Skills Panorama Survey, 2017, "Lithuania: Mismatch Priority Occupations," https://skillspanorama.cedefop.europa.eu/en.

Estevao, M., and E. Tsounta, 2013, "Has the Great Recession Raised U.S. Structural Unemployment?", IMF Working Paper 11/105 (Washington: International Monetary Fund).

Estevao, M., 2003, "Do ALMP Increase Employment?", IMF Working Paper 03/234 (Washington: International Monetary Fund).

Forth, J., and G. Mason, 2006, "Do ICT Skill Shortages Hamper Firms' Performance? Evidence from UK Benchmarking Surveys," National Institute of Economic and Social Research Discussion Papers, No. 281.

IMF, 2014, "Unemployment and Structural Unemployment in the Baltics", Baltic Cluster Report 2014

Kampelmann, S., and F. Rycx, 2012, "The Impact of Educational Mismatch on Firm Productivity: Evidence from Liked Panel Data," I, Vol. 31, Issues 6, 918-931.

Martin, J., 2015, "Activation and Active Labor Market Policies in OECD Countries: Stylized Facts and Evidence on Their Effectiveness," IZA Journal of Labor Policy, Vol. 4, Issue 4.

McGowan, M., and D. Andrews, 2015, "Labor Market Mismatch and Labor Productivity", OECD Economics Department Working Papers No. 1209 (Paris: Organization of Economic Cooperation and Development).

McKenzie, M., 2017, "How Effective Are Active Labor Market Policies in Developing Countries? A Critical Review of Recent Evidence," IZA Discussion Paper No.10655.

OECD, 2018a, "*OECD Economic Surveys: Lithuania 2018*," (Paris: Organization of Economic Cooperation and Development).

———, 2018b, "*OECD Reviews of Labor Market and Social Policies: Lithuania*," (Paris: Organization of Economic Cooperation and Development).

———, 2017, "*Getting Skills Right for Jobs Indicators*," (Paris: Organization of Economic Cooperation and Development).

———, 2016a, "*Getting Skills Right: Assessing and Anticipating Changing Skill Needs*," (Paris: Organization of Economic Cooperation and Development).

———, 2016b, "*OECD Economic Surveys: Lithuania 2016*," (Paris: Organization of Economic Cooperation and Development).

Verhaest, D. and E. Omey, 2006, "The Impact of Overeducation and Its Measurement," *Social Indicators Research,* Vol. 77, Issue 3, 419-448.

THE INTEREST RATE GAP AND FINANCIAL CONDITIONS IN LITHUANIA[1]

Despite sharing a common nominal policy rate, monetary conditions can vary across the euro area countries reflecting differences in characteristics of the domestic economies, stages in the business cycles, and the transmission mechanism via financial markets. Therefore, the natural interest rate—the rate that equates domestic and foreign saving and investment when output is at its potential level and inflation approaches its long-term trend—can also differ across countries. Using the gap between the natural and ECB's rate to assess the stance of monetary policy in Lithuania, we can conclude that policy has been largely accommodating since at least 2011. Monetary policy stance does not always translate into looser financial conditions. Other factors, especially euro area financial factors, have also affected Lithuania's financial conditions, which tightened after the 2009 crisis and only clearly recovered since 2016.

A. Introduction

1. Estimates of the natural interest rate serve as an anchor for conducting and communicating monetary policy. The topic has gathered much attention in the post-crisis era, as there is uncertainty regarding the timing of monetary policy normalization as well as the new 'normal' equilibrium for policy rates. Central bankers in Canada, the U.K., and the U.S., among others, have all referred to natural interest rates in public statements or recent studies.[2] For countries in a currency union, the country-specific natural interest rates, and, thus, monetary policy stance, help assess the optimal stance of other available policy levers, in particular, fiscal and macroprudential.

2. The foundational concept of the natural interest rate was first mentioned by Wicksell back in 1898 as the rate that stabilizes prices. Woodford (2003) and Gali (2008) introduce the natural interest rate (r*) in a modern New Keynesian framework in which r* is an unobservable rate that equates domestic and foreign savings to investments when the economy is at potential. It responds to all real shocks that hit the economy.

3. There are two strands of literature to operationalize this concept. One approach is to model r* as the counterfactual interest rate in the absence of nominal frictions, which suggests that it closes the output gap instantly at any point in time. This is consistent with DSGE modelling where estimates of r* are often volatile and are linear combinations of all transitory shocks. In such DSGE models, preference parameters are constant. A monetary policy rule that can track this r* perfectly period by period, would achieve full macroeconomic stability where the divine coincidence holds (Barsky et al. 2014).[3] Such policy rule works well when demand shocks dominate, and both prices

[1] Prepared by Vina Nguyen. This paper draws the methodologies from two forthcoming IMF Working Papers. "Natural Interest Rates in Europe" and "Financial Conditions in Europe."

[2] Studies done by Bank of England, Canadian Central Bank, and the Fed Chairman's mentioning of the US interest rate being "a long way" and "just below" the neutral rate.

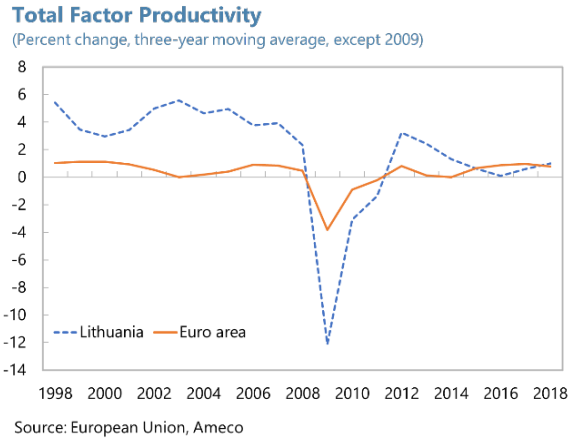
[3] The case in which Central Banks do not face the trade-off between stabilizing inflation and the output gap.

and quantities move in the same direction, but less so in the presence of mark-up supply shocks. In addition, given the large uncertainty around the estimates of the unobservable r* and lags in the impact of monetary policy, tracking a highly volatile estimate of r* may not lead to desirable outcomes, not to mention the challenges of periods when setting the real rate to the estimated r* would imply a negative nominal interest rate.

4. Another approach is a reduced-form framework with time-varying preference parameters. In these semi-structural models, starting with Laubach and Williams (2003), r* is more closely related to trend growth. Without any additional shocks, r* would close the output gap over the medium term when all short-term shocks have dissipated. By including leads and lags in the typical New Keynesian IS curve and Phillips curve equations, these models are more agnostic about the precise relationships among these endogenous variables and therefore, the estimated structural parameters are less affected by misspecifications of these equations (Holston et al. 2017).

5. The well-established uncertainty around estimates of r* calls for caution. This paper, therefore, contrasts the results from several approaches, including those that are based on economic theories—the original Laubach and Williams model (Laubach and Williams 2003 and 2015, Holston et al. 2017) and the extended model (Pescatori and Turunen 2015)—and those that are driven by capital market data (Del Negro et al. 2018 and Christensen et al. 2011). The former models suggest a close relationship between trend growth and r* while the latter reveal what investors expect r* to be given the available information at the time.

6. The natural interest rate in Lithuania has fallen after the crisis, largely driven by the decrease in productivity growth. Over the past two decades, estimates of r* generally show a decline of about two and a half percentage points. However, unlike the gradual decline often observed in advanced economies largely driven by an aging population, r* estimates in Lithuania show a step decline around the crisis, reflecting a sharp decrease in productivity growth. GDP growth averaged 8.1 percent between 1999 and before 2009 and only 3.4 percent after the crisis. This declined was largely driven by TFP growth. While it was remarkably high before the crisis, it halved afterwards. As a small and very open economy without an independent monetary policy, Lithuania is more exposed to external shocks that result in higher volatility. The global financial crisis exposed large imbalances in Lithuania that was fueled by large capital inflows. As capital flows halted, the adjustment was abrupt, but it resulted in an equally fast recovery despite lower productivity growth. In addition, Lithuania has the most severe demographic trends in Europe. While high productivity pre-crisis helped hide the negative impact from demographic, the moderate recovery in productivity since, has only partially offset this trend.



Source: European Union, Ameco

7. Capital market data show periods of divergence between estimates of Lithuania and the euro area r* around the crisis, but convergence in the run up to euro adoption. Following Del Negro et al. (2018), r* is estimated jointly among several euro area (EA) countries, assuming a common factor. The path for r* in Lithuania and the euro area were roughly parallel before the crisis when there was already a currency board, diverged significantly between 2008 and 2014, particularly when redenomination risks increased, and converged again thereafter in the period leading to euro adoption. This convergence implies that for the past several years, capital markets deem the Lithuanian economy integrated into the euro area.

8. The accommodative (exogenous) monetary policy stance over the last two decades has contributed to relaxing financial conditions in Lithuania regardless of the cyclical condition of the economy. As a converging economy, potential growth is higher in Lithuania than in Western Europe, resulting in a higher natural interest rate. However, the ECB sets monetary policy for the whole euro area, which results in policy rates that tend to be too accommodative for Lithuania and has translated into a looser monetary policy stance for Lithuania than warranted by Lithuania specific conditions. This is also true for the period before euro accession given the existence of a currency board. The financial condition index (FCI) captures this as well as a dozen other financial indicators to determine the overall financial conditions in the economy. It indicates that while the stance of monetary policy has been particularly accommodative since 2011, financial conditions have not. The loading coefficient on interest rate gap is rather low and other factors, especially the euro-area-wide financial factors seem to play a more important role. Only after 2016 have financial conditions in Lithuania loosened in a significant way according to the FCI. This contrasts with the Bank of Lithuania's own financial condition index which is based on domestic factors only.

B. The Laubach-Williams Framework

9. In the Laubach-Williams (LW) framework over the medium-to-long-term, r* is driven by similar structural factors that determine potential output. This is consistent with the framework developed by Gali (2008) in a New Keynesian model, which builds on the standard consumption Euler equation to define r* as:

$$r_t^* = \rho + \sigma \frac{1+\varphi}{\sigma(1-\alpha)+\varphi+\alpha} E_t(\Delta a_{t+1}) \qquad (1)$$

where ρ is the household's discount rate over time (degree of patience); σ is the elasticity of substitution in a CES utility function which is assumed to take the value of one in the case of log utility, $(1-\alpha)$ and α are the labor and capital shares of production respectively, φ is the marginal disutility of work, and; a_t is the level of technological progress. Equation 1 shows a direct, but not necessarily one-for-one relationship between potential output and r*.[4]

[4] Rachel and Smith (2017) suggest that because households' value smooth consumption patterns, every percentage point fall in trend productivity growth could cause equilibrium real rates to fall by up to twice as much.

10. The original LW model is then presented as a set of reduced-form linear equations. It includes the standard IS (2) and Phillips curves (5).

$$\tilde{y}_t = \alpha_1 \tilde{y}_{t-1} + \alpha_2 \tilde{y}_{t-2} - \frac{\alpha_r}{2} \sum_{j=1}^{2} \left(r_{t-j} - r^*_{t-j} \right) + \varepsilon_t^{IS} \qquad (2)$$

In equation (2), the natural real rate (r_t^*) is endogenous, while the forward-looking real rate ($r_t = i_t - \pi_t^e$) is exogenous to Lithuania and equal to the difference between the nominal policy rate EONIA (i_t), and the three-year ahead inflation expectations (π_t^e); ε_t^{IS} is an iid shock with standard deviation σ^{IS}. In turn, the output gap is equal to the difference between output (y_t) and potential (y_t^N), $\tilde{y}_t = y_t - y_t^N$

Potential output (y_t^N) is driven by trend growth (g_t) and a temporary i.i.d. shock (ε_t^N) with standard deviation σ^N,

$$y_t^N = y_{t-1}^N + g_{t-1} + \varepsilon_t^N \qquad (3)$$

Trend growth is defined as a random walk with a persistent shock (ε_t^g),

$$g_t = g_{t-1} + \varepsilon_t^g \qquad (4)$$

The specification of the model used in this paper extends the original model to include an open-economy backward looking Phillips Curve relating (core) inflation to the output gap and the gap between domestic currency import price and core inflation,

$$\pi_t = \beta_1 \pi_{t-1} + \frac{\beta_2}{3} \sum_{j=2}^{4} \pi_{t-j} + \frac{1-\beta_1-\beta_2-\beta_0}{4} \pi_{t-5} + \frac{1-\beta_1-\beta_2}{4} \sum_{j=6}^{8} \pi_{t-j} + \beta_y \tilde{y}_{t-1} + \beta_m \pi_{t-1}^m + \varepsilon_t^{PC} \qquad (5)$$

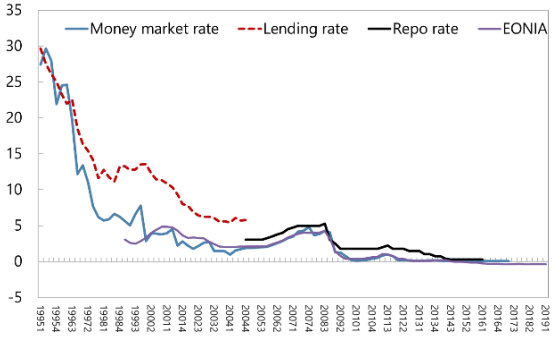
11. Similar to equation (1), the model also pins down the relationship between r* and potential growth. Trend growth (g_t) is assumed to follow a random walk with a persistent shock, and r* is a function of trend growth plus an exogenous process (z_t) capturing other drivers of r* orthogonal to potential growth:

$$r_t^* = c g_t + z_t \qquad (6)$$

where c is a positive constant. Assuming log utility, *c* takes the value of one. In this model, z_t (which is assumed to follow an AR (1) process), r_t^* and g_t (all unobservable) are simultaneously estimated using a Kalman filter.

12. The model is estimated with Bayesian techniques and quarterly data. The key macroeconomic indicators include annualized quarterly output, core inflation, inflation expectations, and import inflation. To assess the monetary policy stance that is exogenous to Lithuania, EONIA is used as the nominal interest rate. In fact, interest rates in Lithuania have converged to euro-wide rates since the early 2000s as the litas was already pegged to the euro since 2002. Before that, lending rates or money-market rates in Lithuania were significantly higher.

Lithuania: Different Rates
(In percents, 1995Q1 - 2018Q4)

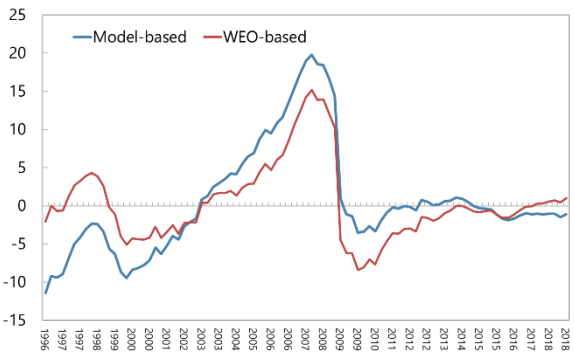


Sources: Bank of Lithuania, Haver Analytics

13. Incorporating additional information from outside the model in the estimation of the output gap improves model results. The LW model jointly estimates the natural interest rate and trend growth. It was designed for a closed economy with the US in mind. Thus, when applying this model to a small open economy such as Lithuania, estimates of trend growth may lead to an implied output gap that is not plausible from an economic point of view. For example, estimates of the output gap for Lithuania show a large negative gap of 10 percent in the mid- and late-90s while the IMF World Economic Outlook (WEO) estimates that, by construction, incorporate more information, provide more reasonable results. The LW model is then modified to incorporate the IMF WEO estimate of potential growth as an additional signal with some signal-to-noise ratio. The resulting output gap estimate in this case is, therefore, a weighted average between the actual and WEO data.

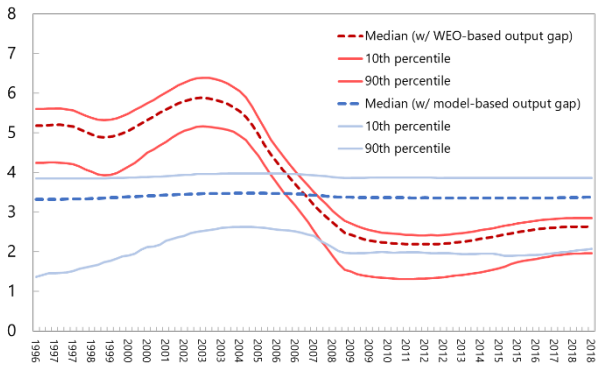
14. The estimated natural interest rates in Lithuania declines during the crisis in contrast to the gradual decline found in core EA countries. The steep drop in r* around the 2008–09 crisis is followed by a small recovery thereafter. The pre-crisis average median estimate of r* is around five percent compared to the post-crisis average of slightly above two percent. The credibility intervals of the r* estimates from using the WEO-based and the model-based output gap largely overlap, especially since 2009.

Lithuania: Output Gap Estimates
(In percent of potential output, 1996Q2-2018Q4)



Sources: IMF Staff Estimates

Lithuania: Natural Interest Rate Estimates
(In percent, 1996Q2-2018Q4,)



Sources: IMF Staff Estimates

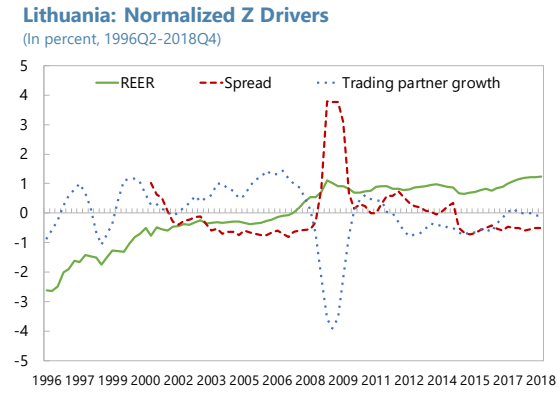
15. The LW model is then further adapted to capture the importance of the capital and current accounts in a small open economy. The main equations of the model, the IS curve and the Phillips curve, can explain the dynamics between the output gap, inflation, and the interest rate gap in either an open or closed economy. However, the original model was first developed for the United States with long data series and an economy less subject to external shocks and, therefore, volatility and a greater reliance on long-term slow-moving drivers of r* such as demographics and technological innovations.

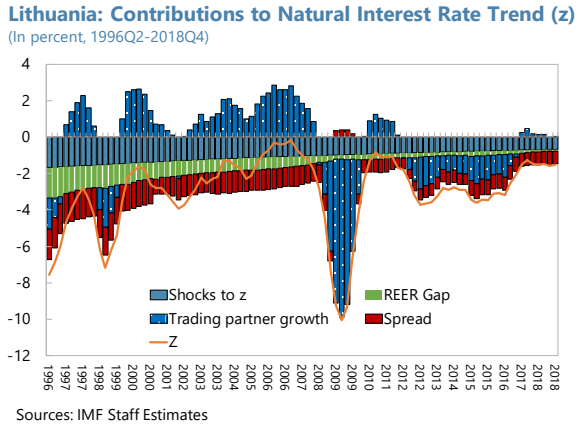
16. The natural interest rate in a small open economy is determined by both domestic and external factors. In an open economy with capital and current account flows, the natural interest rate should also ensure the no-arbitrage condition between real returns of domestic and foreign assets, i.e. the real uncovered interest parity. This arbitrage condition adds to those in a closed-economy context: the consumer is indifferent between current and future consumption; and entrepreneurs are indifferent between investing in real or financial assets. For Lithuania, the real effective exchange rate (REER),[5] trading partner growth and the ten-year government bond spread against the German bunds were considered as possible drivers of r*. The first two are designed to reflect the importance of external conditions on Lithuania through the current account, while spread is used as a proxy for risk premium, especially during the financial crisis, and incorporate the impact of the capital account.

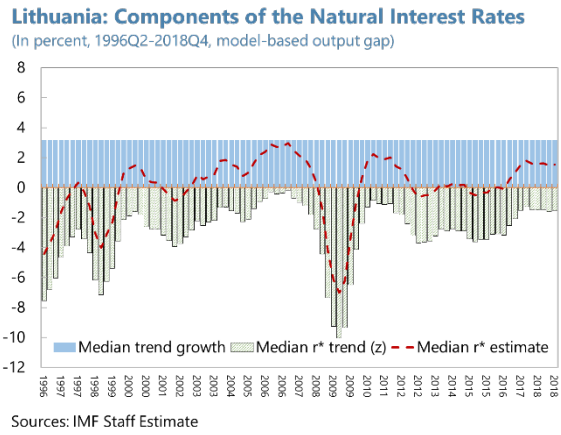
17. Among external factors, trading partner growth has contributed the most to r* dynamics in Lithuania highlighting the open economy nature of the economy. Not surprisingly, including additional factors that reflect the open nature of the economy, has led to a more volatile estimate of r*. For France, Germany, Italy, and Spain, r* also falls during the GFC to a more moderate level below minus two percent. Meanwhile, the Lithuanian median r* estimates dropped to around negative six percent. A significant component of this volatility comes from the fluctuations in trading partner growth. For the past decade, Lithuania's biggest trading partner is Russia and during the 2009-2010 crisis, Russia's GDP dropped by 8 percent.

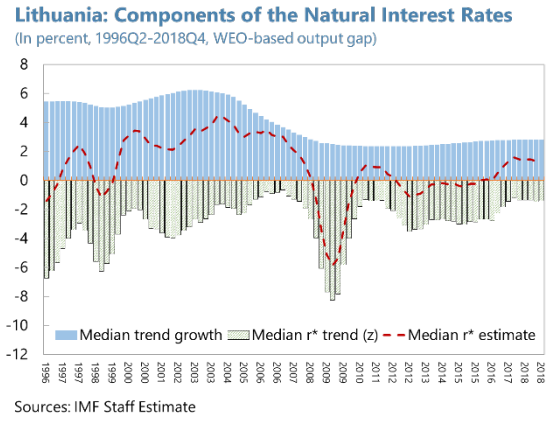
18. The sharp estimated drop of the natural interest rates during the global financial crisis should be interpreted with caution. The once-in-a-lifetime crisis resulted in a reversal in capital flows that, while short-lived, caused an unprecedented correction of the economy. During this period and while redenomination risks emerged, the monetary policy transmission mechanism was effectively inoperative as reflected in the surge in spreads. Within the framework of the model, the sharp decline in the natural interest rates reflects the model dynamics: a widening output gap is countered with accommodating monetary policy to restore equilibrium. When a country faces an economic and confidence shock as severe as Lithuania did in 2009, monetary policy alone cannot restore output to its potential level. There simply doesn't exist an interest rate low enough to stimulate demand. To weather the crisis, Lithuania implemented radical measures that delivered a successful internal devaluation and avoided default without external assistance.

[5] We use the REER gap, measured as the deviation of REER from its long-term average.

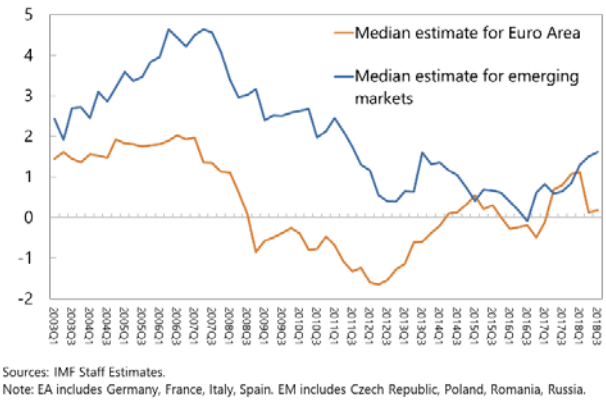


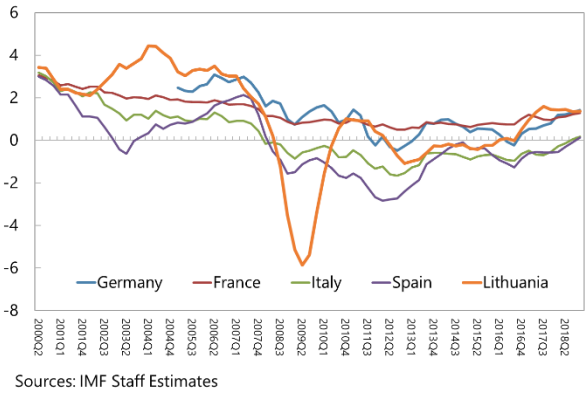






19. During the recovery, the median estimate of r* in Lithuania is better aligned with those of other core EA countries. In 2015, Lithuania adopted the euro and gained access to credit from the ECB that has become the lender-of-last resort, eliminating idiosyncratic redenomination risks going forward. However, as a catching-up economy, potential growth in Lithuania is expected to exceed that of the core EA countries. The median r* estimate in Lithuania between 2014 and 2018 is estimated to be 0.4 percentage points higher than in the largest four economies in the euro area.





C. The Market-implied Natural Interest Rate

20. Financial markets can also be used to provide valuable information about r*. These models tend to exploit the fact that the (observed) real interest rate should fluctuate around the natural interest rate, with the gap between them tending to close as real and nominal shocks dissipate over time. These models tend to be more agnostic about the economic drivers behind these estimates. This paper employs two approaches using market data: the Bayesian VAR model with a common factor (Del Negro et al. 2018) and a term structure model (Christensen et al. 2011).

Bayesian VAR with a Euro Area Common Factor

21. This model explicitly considers Lithuania as part of a currency union. With perfect capital mobility and spillovers from business cycle fluctuations, there should be some co-movements of the natural rates across EA countries. The model by Del Negro et al. (2018) stacks a group of countries in a VAR model to estimate jointly the country-specific trends of real short-term interest rates and the common trend across the whole euro area.

22. The model extracts trends from inflation, real short-term interest rates and real long rates using a Kalman filter with Bayesian estimation techniques. The trend real short rate is used as a low-frequency measure of r*. As inputs, the method uses data on inflation, *nominal* short rates and *nominal* long rates, and assumes that these series are cointegrated as follows:

$$\pi_t = \pi_t^* + e_t \qquad (7)$$

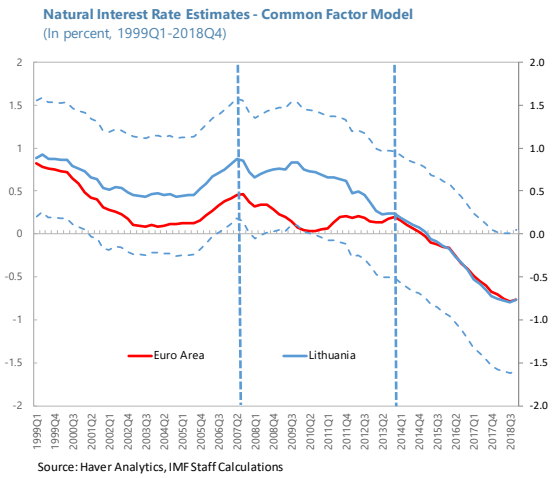
$$i_t^{3m} = \pi_t^* + r_t^* + u_t \qquad (8)$$

$$i_t^{10yr} = \pi_t^* + r_t^* + tp_t^* + v_t \qquad (9)$$

where π_t^* is trend inflation, i_t^{3m} is the three-month T-bill rate, i_t^{10yr} is the 10-year bond yield, tp_t^* is the trend term premia, and e_t, u_t and v_t are shocks (which could be persistent and correlated with each other). The trend components are assumed to follow a random walk and are subject to 'white-noise' shocks. Furthermore, recognizing that Lithuania is a small open economy in a currency union, these trends are jointly estimated for the six largest euro area economies and Lithuania. Common factors on π_t^*, r_t^* and tp_t^* are estimated (the 'euro area factors'), as well country-specific trends.

23. The natural interest rate shows a decline of around two percent after 20 years. Like other EA countries, the median r* estimate for Lithuania has fallen from 0.9 percent to around -0.8 percent at the end of 2018. The EA common factor also shows this decline with almost identical start and end points. Unlike the result from the LW model, the decline in r* here is more gradual and the rebound after the crisis is not sustained, especially after 2014.

24. The period of largest divergence between Lithuania and the EA common factor was during the crisis. Prior to the adoption of the euro, r* in Lithuania is persistently higher than in the core EA countries. The gap slightly widens in the early 2000s, and particularly from 2007 to 2009, at the worst of the crisis. In the runup to euro adoption, the gap starts to close as markets expected more integration and co-movement of business cycles between Lithuania and the rest of the currency union. The risk premium also dissipated without redenomination risk. All throughout the sample period, both median estimates were within the other's 'credibility band'.

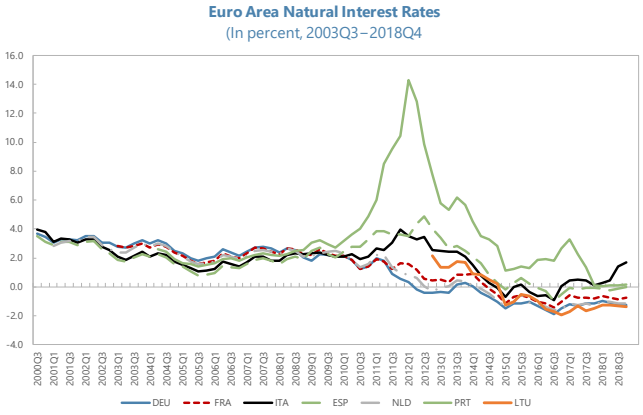


In contrast to the LW model, which emphasizes the importance of potential growth and of trading partners' growth (notably Russia), this approach emphasizes the importance of euro-area-wide factors in determining r* in Lithuania.

The Affine Arbitrage-Free Term Structure Model

25. Financial markets can also provide information on what r* might be in the future. Given that the actual and the natural rate of interest are expected to converge over the medium term (as nominal and real shocks dissipate), financial market data can be exploited to find useful information on the future value of r*. A version of the Nelson-Siegal term structure model (Christensen et al., 2011) is used to fit the yield curve of Lithuanian government debt through time. The model employs the popular dynamic Nelson-Siegal representation of the yield curve and imposes an arbitrage-free condition across time and maturities. From this, the implied path of future nominal short rates (3-month treasury bill), consistent with this yield curve, can be derived and used as a proxy for the (nominal) natural rate, five-years ahead. Again, inflation expectations are used to convert nominal rates into real rates.

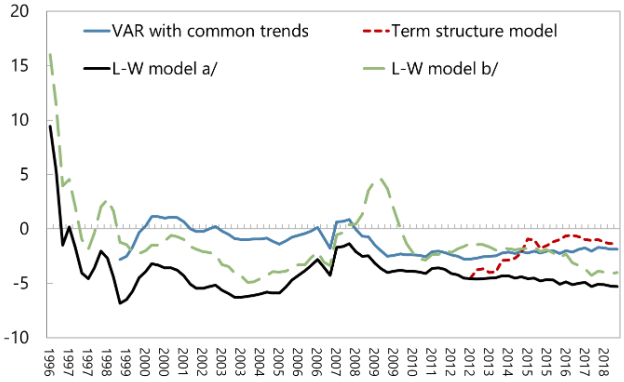
26. Lithuania's r* is expected to hover around negative one percent in coming years. The estimates across countries from this model are significantly lower than from the standard LW model. In addition, Lithuania's r* estimate registers a lower end-point than other core EA countries. With relatively short time series and gaps in the data for government bond yields at different maturities, Lithuania results should be taken with caution.



D. The Interest Rate Gap

27. The interest rate gap is estimated to be persistently negative for Lithuania, implying highly accommodative monetary policy stance. The 'interest rate gap' is measured as the difference between the forward-looking real rate of interest[6] and the natural interest rate. While the results from different methodologies can vary, they point to a monetary policy stance that has been highly accommodative for Lithuania, and more so than for "core" economies in the euro area, especially after the global financial crisis. The implied interest gap using the extended LW model that better captures the characteristics of the Lithuanian economy (model b/ in the figure), implies slightly less accommodative stance than the original model (model a/ in the figure). Importantly, the former model is the only one that captures the tightening in financial condition during the crisis. Both LW models point to more accommodative monetary policy stance than market-derived estimates.

Lithuania: Interest Rate Gaps
(In percent, 1996Q2-2018Q4)



Sources: IMF Staff Estimates

E. Financial Conditions

28. The interest rate gap is one of several components that determine domestic financial conditions. To the extent that the policy rate affects households' intertemporal substitution, the exchange rate and therefore, external balances, other lending rates, asset prices, the deviation between this rate and the medium-term natural rate in the economy are expected to contribute too to a deviation of financial activity, including leverages, from its long-term trend.

29. There is not yet a consensus on how to measure financial conditions. There are two main strands of literature on measuring financial conditions, one focusing on filtering the financial cycle based on a few key indicators (Hatzius 2010, Borio 2012) and another trying to summarize information from a large number of indicators (Chicago Fed National FCI, IMF GFSR 2018). This paper applies the second methodology using the chained-index partial least square approach. The widely used principal component analysis (PCA) selects variables that are orthogonal to the first component that maximizes the variances. However, the variable that happens to have the most variance may not be the most relevant for assessing financial conditions. The PCA could just pick up a variable that is volatile, but does not explain the variable of interest such as credit growth.

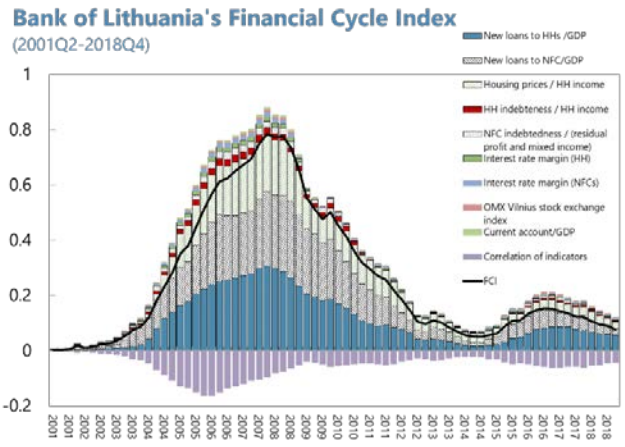
[6] Nominal interest rate minus inflation expectations.

30. Partial least square (PLS) includes a target variable in summarizing information from many indicators. The result, therefore, selects the variables that maximizes the covariances between the dependent (target) and independent variables. If the target variable is credit growth of the whole economy, estimates from the PLS summarize information from a group of indicators that would be most relevant for explaining and predicting credit growth. The goal is to derive an *FCI* using the PLS of a funding variable *F* on a set of factors $G = (g_1 \ldots g_k)$ that are relevant for financial conditions.

$$FCI \text{ such that the covariance } (F, FCI) \text{ is maximized and } G_t = \Lambda\, FCI_t + u_t$$

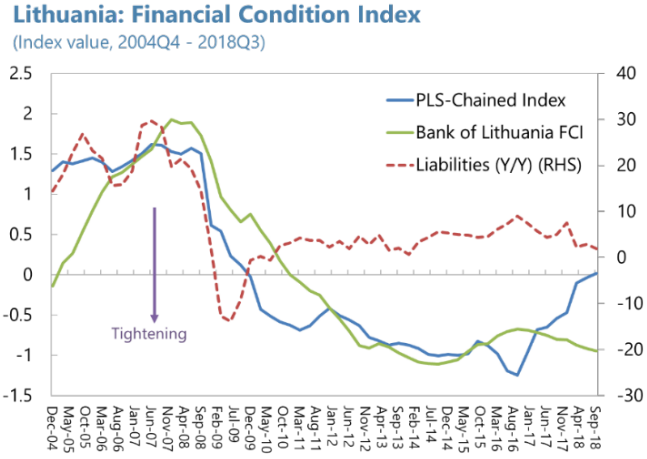
where FCI is a projection (akin to a 'first principal component') of *G* that is also the closest to the funding variable *F*. Λ is a matrix of loadings to be obtained by the PLS algorithm.

31. The PLS indicators selected here include both external and domestic variables. There is no limit to the number of indicators that can be included in the PLS. While the Bank of Lithuania considers mainly domestic variables in their FCI, it is feasible to also include euro area variables that can have spillover effects on Lithuania's credit growth. The variables here cover different interest rates, asset prices, financial soundness indicators, returns from equity and fixed income markets, and various measures of volatility.



Sources: Bank of Lithuania

32. The PLS-chained[7] FCI shows that financial conditions have tightened during the 2009 crisis and loosened since the end of 2016. This is broadly consistent with the monetary policy stance derived from the extended model of LW for Lithuania. The factors with the highest loadings tend to be external factors, such as the euro area shadow rate, euro swap rate, and non-sovereign AAA bond yields. The domestic factors with the highest loading are Lithuania ten-year bond yield and general government interest-expenses-to-revenue ratio. The negative loading coefficient of the negative

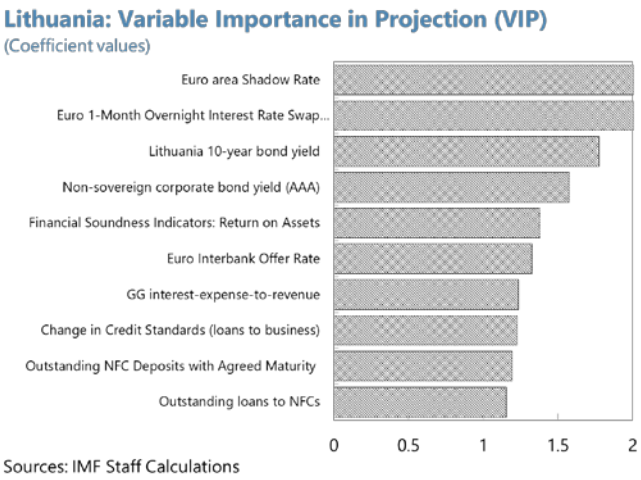


Sources: Bank of Lithuania, IMF Staff Calculations

[7] The PLS algorithm cannot produce a result with missing data, and some financial indicators only became available late in the sample. The PLS-Chained Index methodology produces an index with all the available data at that point in time and as new indicators become available, the index is extended to incorporate new information.

interest rate gap shows that loosening monetary policy has contributed to a loosening of financial conditions and vice versa.

33. The two FCI estimates are mostly aligned except for the recent period since 2016. The FCI produced by the Bank of Lithuania shows a continuing decline since 2016, implying a moderation of the financial cycle while the PLS index shows loosening conditions. The Bank of Lithuania cites several evidences indicating a tightening cycle. These include a higher rejection rate of loan applications by banks[8], a lower risk appetite by banks according to surveys[9,10] and a slowdown in lending to the non-financial corporates. Other indicators are more mixed such as the continued high growth in mortgages and real estate prices. Importantly, the PLS-chained FCI gives a bigger role to external factors.



F. Conclusion

34. Estimates of the Lithuanian interest rate gap suggest a largely accommodating monetary policy stance. After the 2009–10 crisis, estimates of trend growth and r* show a step decline before remaining mostly flat. Over two decades between 1999 and 2018, r* estimates have dropped by around 2 percentage points, which is consistent with the post-crisis decline in potential output. Controlling for external factors results in more volatile r* estimates and reflect the small, open and more volatile nature of the Lithuanian economy. The monetary policy stance for the past six years has been more accommodative for Lithuania than for the 'core' EA countries by roughly 0.5 percentage points and manifests the more advanced cyclical position of the Lithuanian economy relative to the euro area—the focus of ECB's mandate. This gap has contributed to loosening financial conditions. However, the main determinants of financial conditions, that seem to have loosened after 2016, appear to be euro-area-wide financial factors.

[8] Financial Stability Report 2019.

[9] Review of the Survey of Risks to Lithuania's Financial System, 2018. Bank of Lithuania.

[10] Review of Bank Lending Survey 2018, Bank of Lithuania.

Annex I. Calibration of Priors for Key Parameters in the Laubach-Williams Model

The model is calibrated for the economy of Lithuania using quarterly data.

1. **The output gap equation (IS curve):** The parameters are drawn from a constrained regression of output gap on its lagged values and the lagged values of the interest rate gap.

- In this regression, the interest rate gap is proxied by using an HP-filtered real interest rate as the natural rate.
- The coefficients on two lagged interest rate gaps are constrained to be equal, smoothing the lagged impact of monetary policy stance on output gap.
- The coefficients on the lagged output gaps hardly change between the constrained and unconstrained regressions.

2. **The Phillips Curve:** The parameters are based on the regression coefficients where current inflation is determined by the lagged values of inflation, output gaps, import inflation and oil price inflation.

- The coefficients of eight quarters of lagged inflation sum to 1.
- The potential output equation: Potential output is assumed to follow a random walk. Trend year-on-year growth is converted to quarterly growth.

3. **The natural rate equation:** Natural rate is a function of trend growth and other domestic factors. The coefficient of trend growth represents the marginal utility of consumption or the coefficient in CES utility function. As we represent the utility function in the logarithm form, this parameter is assumed to be 1.

4. **The dynamics of the other domestic factors:** The priors for the autocorrelation coefficients of each factor are drawn from independent estimation. When other factors are included, the contributions to Z are assumed to be equal and add up to one.

5. **The distributions of the error terms:** The priors for shock distributions are based on Pescatori and Turunen (2015).

Table 1. Prior and Posterior Distributions of Key Parameters

			No WEO, without Z determinants				No WEO, with Z determinants				With WEO, without Z determinants				With WEO, with Z determinants			
	Description	Prior	Mode	Median	10th	90th	Mode	Median	10th	90th	Mode	Median	10th	90th	Mode	Median	10th	90th
c	elasticity of substitution	1.00	1.01	0.99	0.93	1.06	1.01	0.99	0.93	1.06	0.98	1.00	0.94	1.06	1.02	1.00	0.94	1.07
d1	AR coef. on z	1.00	0.91	0.99	0.70	1.34	0.92	1.03	0.72	1.38	1.00	1.02	0.73	1.35	0.88	1.02	0.74	1.38
rhod	d1+d2 (AR coefs. On z)	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
a1	AR coef. on output gap	1.19	1.22	1.26	1.15	1.37	1.22	1.22	1.12	1.33	1.25	1.20	1.12	1.29	1.19	1.16	1.07	1.27
rhoA	a1 + a2	0.91	0.97	0.95	0.90	0.98	0.97	0.95	0.91	0.97	0.94	0.92	0.88	0.95	0.93	0.92	0.87	0.96
a_r	Coef.on interest rate gap in IS curve	0.06	0.01	0.03	0.01	0.07	0.01	0.09	0.02	0.19	0.01	0.03	0.01	0.07	0.05	0.07	0.02	0.20
by	Coef. On output gap in PC	0.11	0.11	0.11	0.10	0.13	0.11	0.11	0.10	0.13	0.11	0.11	0.10	0.13	0.11	0.11	0.10	0.13
b1	AR coef. On inflation in PC	0.47	0.32	0.34	0.26	0.43	0.32	0.33	0.25	0.42	0.30	0.36	0.27	0.44	0.39	0.35	0.27	0.43
b2	AR coef. On further lags in inflation in PC	0.18	0.38	0.50	0.36	0.62	0.38	0.50	0.35	0.63	0.53	0.52	0.36	0.66	0.53	0.54	0.39	0.66
dc	weight in z equation for REER gap	0.25					0.26	0.25	0.13	0.39					0.32	0.22	0.10	0.35
de	weight in z equation for trading partner growth	0.25					0.04	1.63	-0.14	2.81					2.01	1.45	0.13	2.67
dp	weight in z equation for spread	0.25					0.76	0.17	-0.92	1.22					-0.73	0.12	-1.07	1.33
lambdag	variation in trend growth	0.90	0.27	0.39	0.22	0.89	0.27	0.37	0.21	0.70	10.60	8.86	6.90	11.44	11.86	11.07	9.76	12.18
lambdaz	variation in r* trend	0.20	0.18	0.26	0.15	0.71	0.18	0.25	0.14	0.42	0.21	0.25	0.15	0.71	0.17	0.26	0.15	0.49
eps_n	Shock to potential output eq.	0.53	0.20	0.99	0.26	3.26	0.20	0.60	0.22	2.51	0.14	0.19	0.14	0.26	0.17	0.19	0.14	0.26
eps_IS	Shock to IS curve	0.70	2.69	2.47	1.23	2.82	2.69	2.45	1.60	2.81	2.62	2.55	2.32	2.84	2.61	2.51	2.26	2.80
eps_PC	Shock to PC	0.81	3.98	3.83	3.45	4.29	3.97	3.81	3.46	4.24	3.49	3.79	3.43	4.20	3.81	3.78	3.43	4.22
eps_nu	Shock to output gap noise	0.50	1.70	1.70	1.55	1.87	1.70	1.70	1.52	1.88	0.28	0.28	0.25	0.32	0.28	0.28	0.25	0.32
eps_me	Shock to output gap signal	0.50	0.46	0.44	0.37	0.55	0.46	0.46	0.38	0.56	0.26	0.25	0.22	0.28	0.25	0.25	0.22	0.28

References

Arena, Marco and others, 2019, "Natural Interest Rates in Europe", forthcoming IMF Working Paper.

Barsky, R, A. Justiniano, and L. Melosi, 2014, "The Natural Rate of Interest and its Usefulness for Monetary Policy," *American Economic Review: Papers & Proceedings*, Vol. 104, No. 5, pp. 37–43.

Borio, C., M. Drehmann, and K. Tsatsaronis, 2009, "Financial Stress: What It Is, How Can It Be Measured, and Why Does It Matter?" *Economic Review* Second Quarter (Kansas City, KS: Kansas City Federal Reserve Bank of Kansas City).

Christensen, J. H.E., F. Diebold, and Glen Rudebusch, 2011, "The Affine Arbitrage-Free Class of Nelson-Siegel Term Structure Models," *Journal of Econometrics*, Vol 164, No. 1, pp. 4–20.

Del Negro, and others, 2018, "Global Trends in Interest Rates," Federal Reserve Bank of New York Staff Report No. 866 (New York).

European Department Financial Sector Working Group, 2019, "Financial Conditions in Europe", forthcoming IMF Working Paper.

Galí, Jordi, 2008, Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework (New Jersey: Princeton University Press).

Hatzius, Jan, and others, 2010, "Financial Conditions Indexes: A Fresh Look After the Financial Crisis," NBER Working Paper No. 16150 (Cambridge, MA: National Bureau of Economic Research).

Holston, K., T. Laubach, and J. C. Williams, 2017, "Measuring the Natural Rate of Interest: International Trends and Determinants," *Journal of International Economics*, Vol. 108, Supplement 1, pp. S39–S75.

Kiley, Michael T, 2015, "What Can the Data Tell Us About the Equilibrium Real Interest Rate?" FEDS Working Paper, No. 2015–077 (Washington, DC: Federal Reserve Board).

Krippner, Leo, 2015, *Zero Lower Bound Term Structure Modeling: A Practitioner's Guide* (New York: Palgrave-Macmillan).

Laubach, Thomas and John C. Williams, 2003, "Measuring the Natural Rate of Interest," *Review of Economics and Statistics*, Vol. 85, No. 4, pp. 1063–70.

Lunsford, Kurt G. and Kenneth D. West, 2018, "Some Evidence on Secular Drivers of U.S. Safe Real Rates," NBER Working Paper No. w25288 (Cambridge, MA: National Bureau of Economic Research).

Pescatori, Andrea and Jarkko Turunen, 2015, "Lower for Longer; Neutral Rates in the United States," IMF Working Papers 15/135 (Washington: International Monetary Fund).

Rachel, Lukasz and Thomas D. Smith T, 2017, "Secular Drivers of the Global Real Interest Rate," *International Journal of Central Banking*, Vol 3. No 13.

Schüler, Yves S., Paul P. Hiebert, and Tuomas A. Peltonen, 2017, "Coherent Financial Cycles for G7 Countries," ESRB Working Paper Series No. 43 (Frankfurt, Germany: European Systemic Risk Board).

Summers, Lawrence, 2014, "U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound," *Business Economics*, Vol 49, Issue 2.

Wicksell, Knut, 1936, *Interest and Prices*, originally published in 1898, translated by R.F. Kahn (London: Macmillan Publishers).

Woodford, Michael, 2003, *Interest and Prices: Foundations of a Theory of Monetary Policy* (New Jersey: Princeton University Press).

Wu, Jing Cynthia and Fan Dora Xia, 2016, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound," *Journal of Money, Credit, and Banking*, Vol. 48, Issue 2–3, pp. 253–291.