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TIME-VARYING IMPACT OF FISCAL SHOCKS OVER GDP GROWTH IN PERU: AN EMPIRICAL APPLICATION USING HYBRID TVP-VAR-SV MODELS

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Time-Varying Impact of Fiscal Shocks over GDP Growth in Peru: An Empirical Application using Hybrid TVP-VAR-SV Models

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Abstract

This paper estimates hybrid TVP-VAR-SV models suggested by Chan and Eisentat (2018a) in order to identify and quantify the impact of fiscal shocks on the GDP growth of Peru during 1995-2018. According to Bayesian criteria, the best model presents time-varying dynamics but not in all parameters. The results suggest: (i) fiscal shocks are significant according to the calculus of the IRFs, FEVD and HD of the GDP growth; (ii) tax revenue shocks are less important and their impact depends on the selected model and the quarter when the shock occurs; (iii) effect of capital expenditure shocks are the most important drivers of GDP growth; (iv) both fiscal expenditure shocks have been growing over the last 20 years. Finally, we suggest constant revisions of the fiscal multipliers and we think that in the following years, countercyclical fiscal policy in Peru should be mostly driven by capital expenditure.

JEL Codes: C11, C32, E62, H30.

Keywords: Fiscal Multipliers, Fiscal Policy, Hybrid TVP-VAR-SV Models, Bayesian Methods, Peruvian Economy.

Resumen

Este documento estima los modelos híbridos TVP-VAR-SV sugeridos por Chan y Eisentat (2018a) para identificar y cuantificar el impacto de los choques fiscales en el crecimiento del PIB del Perú durante 1995-2018. Según los criterios Bayesianos, el mejor modelo presenta una dinámica variante en el tiempo, pero no en todos los parámetros. Los resultados sugieren: (i) los choques fiscales son significativos de acuerdo con el cálculo de las IRFs, FEVD y HD del crecimiento del PIB; (ii) los choques de ingresos fiscales son menos importantes y su impacto depende del modelo seleccionado y del trimestre en que ocurre el choque; (iii) el efecto de los choques de gasto de capital son los impulsores más importantes del crecimiento del PIB; (iv) ambos choques de gasto fiscal han estado creciendo en los últimos 20 años. Finalmente, sugerimos revisiones constantes de los multiplicadores fiscales y creemos que en los años siguientes, la política fiscal contracíclica en Perú debería estar impulsada principalmente por el gasto de capital.

Clasificación JEL: C11, C32, E62, H30.

Palabras Claves: Multiplicadores Fiscales, Política Fiscal, Modelos TVP-VAR-SV Híbridos, Métodos Bayesianos, Economía Peruana.

Time-Varying Impact of Fiscal Shocks over GDP Growth in Peru: An Empirical Application using Hybrid TVP-VAR-SV Models[1]

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1 Introduction

The long going theoretical debate about the macroeconomic role of fiscal policy hasn't found consensus yet. Keynesian theory argues for strong potential to stimulate aggregate demand whereas Neoclassical theory argues for limited capacity to determine GDP. However, empirical fiscal policy research has resurged since the global financial crisis. In a context where policy interest rates are equal to zero and output gap is persistently negative, use of fiscal policy instruments as efective countercyclical tools has been reconsidered.

For the Peruvian case, most studies find that fiscal policy has been effective, at least from the expenditure side. Thus, an exogeneous increase in 1 unit of public expenditure generates additional units of GDP equal to the estimated fiscal multiplier. However, the disadvantage of most of these studies is that fiscal multipliers are assumed constant over a period of time or that change only between boom and bust cycles.

A first way to address this limitation could be estimating a time-varying parameter vector autoregression model with stochastic volatility (TVP-VAR-SV). However a fully-fledged model can result in overparameterization, which could reflect spurious dynamics of elements that might be constant over time. Therefore, through the estimation of hybrid models (H-TVP-VAR-SV) like Chan and Eisenstat (2018a), we present substantial improvements to determine fiscal policy's strength. The methodology's advantage relies in its flexibility, some parameters are allowed to change over time in some equations while other equations parameters remain constant, resulting in more parsimonious and efficient models to calculate fiscal multipliers that can (or not) change over time.

The first objective of this paper is to find if all, some or none of the parameters that associate fiscal variables with macroeconomic activity and determine fiscal multipliers are time-varying. Using log marginal likelihood and Bayes factor, we compare the results of a TVP-VAR-SV and a constant vector autoregression with stochastic volatility (CVAR-SV) with the results from H-TVP-VAR-SV models. We find that best models assume that most parameters are time-varying; nevertheless, models in which equations that determine GDP are constant cannot be discarded.

With the best models selected, the second objective of this paper is to determine the impact of fiscal policy on GDP calculating fiscal multipliers. As most of the applied research in Peru, we consider crucial to divide public non-financial expenditure into current and capital expenditure due

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to the higher productivity associated with public investment. To broaden our analysis, we also present and discuss traditional outputs of VAR literature like impulse response functions, forecast error variance decompositions and historical decompositions. Additionally, we present a policy application to compare our results with those reported by the Central Reserve Bank of Peru and the Fiscal Council. Finally, to verify consistency, we consider a set of robustness exercises where the sensitivity of our results is evaluated.

Results indicate that both current and capital expenditure shocks have a positive time-varying impact on GDP in all robustness exercises; furthermore, these shocks have important contributions to forecast error variance decomposition and historical decomposition of GDP. On the other hand, a negative response of GDP to positive tax revenue shocks is model-dependent and inconsistent in some robustness exercises, resulting in small contributions to variance decomposition and historical decomposition of GDP. These results are directly reflected in fiscal multipliers, being expenditure ones strictly higher in absolute value than tax revenue ones, especially for capital expenditure. On fiscal multipliers dynamics, we find that expenditure multipliers, especially capital multipliers, exhibit an upward trend since the 90s until 2018, while tax revenue multipliers are found to be small and relatively stable over time or exhibit non-significant dynamics. Finally, our policy application is consistent with the results reported by the Central Reserve Bank of Peru and the Fiscal Council, acting like a weighted average of these results for 2011-2015 and giving more importance to fiscal shocks in recent years. These results suggest that fiscal multipliers should be constantly updated, and that countercyclical fiscal policy should be driven by public expenditure, mostly capital expenditure.

The rest of this document is ordered as follows. Section 2 summarizes modern international literature and details applied empirical literature for Peru. Section 3 describes Chan and Eisenstat's (2018a) methodology to estimate H-TVP-VAR-SV models and the construction of selection criteria. Section 4 presents the data, identification scheme, evidence for time-varying parameters, selection of the best models, impulse response functions, forecast error variance decompositions, historical decompositions, fiscal multipliers analysis, the policy application and other results. Section 5 presents the robustness analysis and Section 6 concludes.

2 Literature Review

2.1 International

Quantification of fiscal policy's capacity to stimulate economic activity usually requires econometric procedures to account for double causality between fiscal and macroeconomic variables. After that is addressed, the traditional way to present and compare results is through fiscal multiplier estimation.

Two of the first papers to empirically estimate fiscal multipliers where Ando and Modigliani (1969) and Barro (1981). The former accomplished this through a large-scale multiple equation model whereas the latter through an instrumental variable (IV) regression. Both papers found mixed results for government spending in the USA. Ando and Modigliani (1969) found aggregate multipliers were higher than 1 in most estimations. In contrast, Barro (1981) found multipliers smaller than 1 and close to 0 depending of the type of spending.

Through VAR models, one of the most cited modern papers to estimate fiscal multipliers is Blanchard and Perotti (2002). Authors impose short-run restrictions based on previous research, like a tax revenue to GDP elasticity or institutional knowledge about the transfer and expenditure system, to identify a structural VAR model (SVAR) of government spending, net taxes and GDP. Authors find that for USA, both negative tax shocks and positive spending shocks have a positive impact on GDP, resulting in one-year multipliers of -0.74 and 0.45. Other result they find is that the impact of fiscal policy over GDP components is differentiated. An exogenous increase in government spending has a positive impact in consumption like in Keynesian theory while that same shock or an increase in taxes has a negative effect over investment as in Neoclassical theory.

For Chile and Colombia, Restrepo and Rincon (2006) calculate fiscal multipliers using SVAR and structural vector error correction models (SVEC) using data between 1990 and 2005. For the Chilean case, the authors find that public expenditure multiplier is positive and tax multiplier is negative; however, for the Colombian case authors find multipliers very close to zero. According to the authors, the difference between both countries is explained by a more prudent fiscal management of the Chilean economy against a laxer fiscal management in Colombia for the analyzed period.

In a similar spirit, Kuttner and Posen (2002) for Japan and Borg (2014) for Malta estimate expenditure and tax multipliers. The former authors find that tax multipliers are higher than expenditure multipliers and through a historical decomposition argue that in most of the 90s fiscal policy was contractive. In contrast, the latter authors find that expenditure multipliers are higher than tax multipliers and that the effect over GDP components is similar to the effect found in Blanchard and Perotti (2002).

Following the methodology proposed by Canova and De Nicolo (2002) and Uhlig (2005), Mountford and Uhlig (2009) identify an SVAR imposing sign restrictions. Using data between 1955 and 2000 for USA, the authors only restrict the response of shocks that don't have a fiscal interpretation, such as business cycle and monetary shocks, resulting in an agnostic identification. Authors conclusions are very similar to those of Blanchard and Perotti (2002) and it is highlighted that the biggest impact over GDP is obtained by deficit financed tax cuts.

In the aftermath of the global financial crisis, especial interest to determine if fiscal multipliers are higher in recession surged. In this context, Auerbach and Gorodnichenko (2012) propose the estimation of a smooth transition VAR (ST-VAR) in the same fashion as univariate smooth transition models (STAR). Taking as a threshold the 7-quarter moving average of GDP growth and quarterly data from 1947 to 2008, authors find that, at least from de expenditure side, fiscal multipliers are higher during crisis taking values between 1 and 1.5 in recession and between 0 and 0.5 in expansion.

Auerbach and Gorodnichenko (2013) extend their previous work for a group of OECD countries. Using biannual expenditure forecasts to identify structural shocks and a shorter time period, authors simplify the ST-VAR methodology considering a univariate panel data estimation. Their broad results prove to be robust because on average fiscal multipliers tend to be higher under recession. These results are also seen in Auerbach and Gorodnichenko (2017) that present fiscal multipliers in expansion and recession for public consumption in Japan between 1960 and 2012. However, using rolling estimations for the Japanese case, authors warn that fiscal policy's capacity to stimulate aggregate demand isn't clear in the last years of the sample due to parameter instability to calculate fiscal multipliers.

To allow even more freedom for parameter estimation, Berg (2015) uses a TVP-VAR-SV model to evaluate the impact of fiscal policy in Germany between 1970 and 2013. The estimation method is based on the methodology proposed by Primiceri (2005) adding expenditure forecasts like in Auerbach and Gorodnichenko (2012, 2013 and 2017) and GDP forecasts to a model that also includes observed expenditure and GDP. The author finds that expenditure multiplier is time-varying taking higher values at the beginning and the end of the sample, exhibiting a "U" shape. Lastly, the author discusses about determinants of multipliers dynamics and finds that the most important are business uncertainty, financial volatility, fiscal sustainability and the entrance to the monetary union.

Another application of time-varying fiscal multipliers is Glocker et al. (2019). Authors study government expenditure multipliers in the United Kingdom estimating a time-varying parameter factor augmented VAR model (TVP-FAVAR) with quarterly data from 1960 to 2015. Multipliers are found to be time varying and their dynamic is mostly explained by business cycles, taking a similar value (positive and smaller than 1) during normal times and higher values (higher than 1) during crises in the 70s and 2008-2009. Authors emphasize that structural variables do not impact multiplier size as there is no clear trend found in the results.

Other approaches to calculate fiscal multipliers that aren't detailed in this paper are the narrative approach presented in Romer and Romer (2010) and the use of DSGE models like in Christiano et al. (2011). The former consists in constructing a series of discretional fiscal policy shocks through historical revision of law costing, while the latter considers calculation of fiscal multipliers when the interest rate is zero. For a broader literature review, Ilzetzki et al. (2013) is recommended for developing economies, Batini et al. (2014) and Favero and Karamysheva (2015) for international experience, Mustea (2015) and Whale and Reichling (2015) for USA, and Warmedinger et al. (2015) for the European Union.

2.2 Empirical Applications for Peru

For the Peruvian case, the first reference is Mendoza and Melgarejo (2008). The authors estimate an SVAR model using quarterly data from 1980 to 2006 following Blanchard and Perotti (2002). Even though explicit multipliers aren't estimated, authors find that both public expenditure and tax revenue shocks can impulse GDP growth. Authors conclude that this effect is amplified restricting the estimation sample from 1990 to 2006 due to public finance strengthening in the 90s and 2000s against fragile fiscal balances in the 80s.

Following a similar application, papers such as Rossini et al. (2011), BBVA (2014) and Consejo Fiscal (2018) calculate fiscal multipliers but differencing between current and capital expenditure. Rossini et al. (2011) find that one-year current expenditure multiplier is 0.59, capital expenditure multiplier is 2.46, and tax revenue multiplier is -0.32. BBVA (2014) estimates that current expenditure multiplier is around 0.3, capital expenditure multiplier is around 1.5 and tax revenue multiplier reaches -0.2. Finally, Consejo Fiscal (2018) finds similar results reporting fiscal multipliers of 0.96, 1.08 and -0.23 for current expenditure, capital expenditure and tax revenue, respectively.

To estimate the size of fiscal multipliers in expansion and recession, Sanchez and Galindo (2013) estimate a ST-VAR model like in Auerbach and Gorodnichenko (2012). Authors find that the expenditure multipliers are between 0.5 and 0.6 in expansion and around 1.3 in recession. For tax revenue multipliers, authors find that its value is close to zero in expansion and between -0.1 and -0.25 in recession. Other papers such as Salinas and Chuquilín (2013), BCRP (2012), MEF (2015) and Vtyurina and Leal (2016) find similar results dividing public expenditure in current and capital expenditure.

Salinas and Chuquilín (2013) find that current and capital expenditure multipliers within a year are 0.14 and 0.63 in expansion and 0.80 and 1.17 in recession. BCRP (2012) finds that current and capital expenditure multipliers are 0.46 and 0.75 in expansion and 1.22 and 1.53 in recession. MEF (2015) finds that government consumption and public investment multipliers are 0.82 and 1.74 when economic growth is high and 0.95 and 1.69 when economic growth is low. Another result from MEF (2015) is that the probability to pass from a low economic growth regime to a high economic growth regime is higher when there are public investment shocks rather than government consumption shocks. Lastly, Vtyurina and Leal (2016) find that current expenditure multiplier is not significant in expansion or recession and that tax revenue multiplier has small significance. However, in the same manner as the aforementioned papers, it is shown that capital expenditure multiplier is positive and higher during crises reaching values, after three years, of 1.1 in recession and 0.5 in expansion.

Finally, a first paper that considers time-varying multipliers for Peru is Guevara (2018). The author estimates a TVP-VAR-SV as in Primiceri (2005) including public expenditure, tax revenue, economic activity and other macroeconomic control variables. Identifying the model through sign restrictions like in Uhlig (2005), the author finds that the public expenditure multiplier is time-varying and higher than 1. The author also analyses multipliers determinants and concludes that the most important for Peru are the debt over GDP ratio and business cycles. For tax revenue, the author finds that on average, an unexpected increase (decrease) of taxes increases (decreases) GDP.

Other papers that differ the methodological approach of this document are also worth noting to explain the history of fiscal variables in Peru. Santa Maria et al. (2009) do a detailed count of most of the expenditure and tax policies implemented from the 80s to the 2000s, while Lahura and Castillo (2018) and Ganiko and Merino (2018) give more detail on tax policies until 2017. More recent references are Ganiko and Montoro (2018), where different sets of fiscal rules are evaluated; Jimenez et al. (2018), where dynamics of subnational investment are analyzed; Rojas and Vassallo (2018), where cyclicity of fiscal policy is discussed; and Ganiko and Rojas (2019), where materialization of fiscal risks are identified through retrospective analysis. Additionally, the Multiannual Macroeconomic Framework (and its revisions or updates) published by the Ministry of Economy and Finance (MEF) can be a useful tool to document fiscal policy stance. Finally, for a more historic revision on fiscal policy in Peru, Martinelli and Vega (2018) is suggested.

3 Methodology

3.1 Econometric Model

As in Chan and Eisenstat (2018a), the TVP-VAR-SV model is specified as follows:

$$\mathbf{A}_t\mathbf{y}_t = \mathbf{b}_t + \mathbf{B}_{1,t}\mathbf{y}_{t-1} + ... + \mathbf{B}_{p,t}\mathbf{y}_{t-p} + \boldsymbol{\epsilon}_t, \tag{1}$$

where $\boldsymbol{\epsilon}_t \sim N(0, \boldsymbol{\Sigma}_t)$, $\mathbf{y}_t$ is the vector of endogenous variables, $\mathbf{b}_t$ is a $n \times 1$ vector of time-varying intercepts, and $\mathbf{B}_{1,t}, ..., \mathbf{B}_{p,t}$ are $n \times n$ matrices of time-varying coefficients associated to lagged vectors of endogenous variables. The coefficient matrix $\mathbf{A}_t$ is a $n \times n$ lower-triangular matrix of contemporaneous time-varying relationships and the vector of structural shocks, $\boldsymbol{\epsilon}_t$, is $n \times 1$ vector with a variance-covariance matrix $\boldsymbol{\Sigma}_t = \text{diag}\left(\exp\left(h_{1,t}\right), ..., \exp\left(h_{n,t}\right)\right)$. It is assumed that each of the log-volatilities $h_t = (h_{1,t}, ..., h_{n,t})'$ follow independent random walks with initial conditions $h_{i,0}$ as parameters to be estimated:

$$h_{i,t} = h_{i,t-1} + \zeta_{i,t}, \tag{2}$$

where $\zeta_{i,t} \sim N(0, \sigma^2_{i,h})$.

Equation (1) is in structural form and the variance-covariance matrix of the structural shocks, $\boldsymbol{\Sigma}_t$, is diagonal by construction. Henceforth, each equation to determine endogenous variable i at time t is expressed as follows:

$$y_{i,t} = -\sum_{j=1}^{i-1} a_{i,j,t}y_{j,t} + b_{i,t} + \sum_{j=1}^{n} b_{i,j,1,t}y_{j,t-1} + ... + \sum_{i=1}^{n} b_{i,j,p,t}y_{j,t-p} + \epsilon_{i,t}, \tag{3}$$

where $\epsilon_{i,t} \sim N(0, e^{h_{i,t}})$.

Each variable $y_{i,t}$, recursively depends on the rest of the variables by contemporaneous time-varying coefficients $a_{i,j,t}$, a time-varying constant $b_{i,t}$, lagged variables associated to coefficients

$b_{i,j,p,t}$, and a structural shock $\epsilon_{i,t}$. According to Chan and Eisenstat (2018a), all exogenous variables can grouped into a vector $\mathbf{x}_{i,t}$ with an associated coefficient vector $\boldsymbol{\theta}_{i,t}$ simplyfing equation (3):

$$y_{i,t} = \mathbf{x}_{i,t}\boldsymbol{\theta}_{i,t} + \epsilon_{i,t}, \tag{4}$$

where $\mathbf{x}_{i,t} = (-y_{1,t}, ., . - y_{i-1,t}, 1, y_{1,t-1}, ...y_{n,t-1}, ..., y_{1,t-p}, ..., y_{n,t-p})'$ and $\epsilon_{i,t} \sim N(0, e^{h_{i,t}})$, and coefficient vector $\boldsymbol{\theta}_{i,t} = (a_{i,1,t}, ..., a_{i,i-1,t}, b_{i,t}, b_{i,1,1}, ..., b_{i,n,1}, ..., b_{i,1,p}, ...b_{i,n,p})'$. Considering the initial conditions, $\boldsymbol{\theta}_{i,0}$, as parameters to estimate, it is assumed that $\boldsymbol{\theta}_{i,t}$ follows a random walk:

$$\boldsymbol{\theta}_{i,t} = \boldsymbol{\theta}_{i,t-1} + \eta_{i,t}, \tag{5}$$

where $\eta_{i,t} \sim N(0, \Sigma_{\theta_i})$.

The TVP-VAR-SV model in Primiceri (2005), presented in previous equations and used in Berg (2015) and Guevara (2018), assumes that all of the models equations have time-varying parameters. The addvantage of hybrid models as in Chan and Eisenstat (2018a) is that not necessarily every equation has to be time-varying. Therefore, it can be proposed that all, some or none of the equations of the VAR model are expresed in the following way:

$$y_{i,t} = \mathbf{x}_{i,t}\overline{\theta_i} + \epsilon_{i,t}, \tag{6}$$

where $\epsilon_{i,t} \sim N(0, e^{h_{i,t}})$, and coefficient vector, $\overline{\theta_i}$, isn't indexed by time and depends only in the endogenous variable to determine.

3.2 Model Selection Criteria

We use log marginal likelihood and Bayes factor as criteria for model selection. As mentioned in Chan and Eisenstat (2018a), using equation (4) reduces the dimension of the importance sampling estimator used for the marginal likelihood, reducing computational time to a reasonable amount. Following Chan and Eisenstat (2018a), the marginal likelihood of the model is defined as the next integral:

$$p\left(\mathbf{y}\right) = \int p\left(\mathbf{y}|\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) p\left(\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) d\left(\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right), \tag{7}$$

where $p\left(\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right)$ is the prior density and

$$p\left(\mathbf{y}|\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) = \int p\left(\mathbf{y}|\boldsymbol{\theta}, \mathbf{h}, \boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) p\left(\boldsymbol{\theta}, \mathbf{h}|\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) d\left(\boldsymbol{\theta}, \mathbf{h}\right), \tag{8}$$

is defined as the integrated likelihood, which is the marginal density of the data unconditional to the time-varying parameter vector $\boldsymbol{\theta}$ and the stochastic volatility vector $\mathbf{h}$. To evaluate the integrated likelihood, Chan and Eisenstat (2018b) propose an importance sampling estimator for which the conditional likelihood of the data to $\boldsymbol{\theta}$ and $\mathbf{h}$ is defined as:

$$p\left(\mathbf{y}|\boldsymbol{\theta}, \mathbf{h}, \boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}\right) = p\left(\mathbf{y}|\boldsymbol{\theta}, \mathbf{h}\right) = \prod_{i=1}^{n} p\left(y_i|\boldsymbol{\theta}_i, \mathbf{h}_i\right), \tag{9}$$

where each component of the product is at the same time product of T univariate Gaussian densities implied in (4). As $\mathbf{h}_{i,t}$ y $\boldsymbol{\theta}_{i,t}$ follow random walks specified in (2) and (5), their joint density can be decomposed as:

$$p\left(\boldsymbol{\theta},\mathbf{h}|\boldsymbol{\Sigma}_{\theta},\boldsymbol{\Sigma}_{h},\boldsymbol{\theta}_{\mathbf{0}},\mathbf{h}_{\mathbf{0}}\right)=\prod_{i=1}^{n}p\left(\boldsymbol{\theta}_{i}|\boldsymbol{\Sigma}_{\theta_{i}},\boldsymbol{\theta}_{i,\mathbf{0}}\right)p\left(\mathbf{h}_{i}|\sigma_{i,h}^{2},h_{i,0}\right). \tag{10}$$

Therefore, the integrated likelihood can be rewritten as:

$$p\left(\mathbf{y}|\boldsymbol{\Sigma}_{\theta},\boldsymbol{\Sigma}_{h},\boldsymbol{\theta}_{\mathbf{0}},\mathbf{h}_{\mathbf{0}}\right)=\prod_{i=1}^{n}\int p\left(y_{i}|\boldsymbol{\theta}_{i},\mathbf{h}_{i}\right)p\left(\boldsymbol{\theta}_{i}|\boldsymbol{\Sigma}_{\theta_{i}},\boldsymbol{\theta}_{i,\mathbf{0}}\right)p\left(\mathbf{h}_{i}|\sigma_{i,h}^{2},h_{i,0}\right)d\left(\boldsymbol{\theta}_{\mathbf{i}},\mathbf{h}_{\mathbf{i}}\right), \tag{11}$$

which is equivalent to:

$$p\left(\mathbf{y}|\boldsymbol{\Sigma}_{\theta},\boldsymbol{\Sigma}_{h},\boldsymbol{\theta}_{\mathbf{0}},\mathbf{h}_{\mathbf{0}}\right)=\prod_{i=1}^{n}\int p\left(y_{i}|h_{i},\boldsymbol{\Sigma}_{\theta_{i}},\boldsymbol{\theta}_{i,0}\right)p\left(\mathbf{h}_{i}|\sigma_{i,h}^{2},h_{i,0}\right)d\mathbf{h}_{\mathbf{i}}. \tag{12}$$

In (12) the first term in the right side of the equation is the density of the data marginal of $\boldsymbol{\theta}_{\mathbf{i}}$, while the second term is the prior density of $\mathbf{h}_{\mathbf{i}}$ implied by equation (2). Using this expression, Chan and Eisenstat (2018a) estimate the integrated likelihood and then use the cross-entropy method proposed in Chan and Eisenstat (2015) to integrate out time-invariant parameters; $\boldsymbol{\Sigma}_{\theta}, \boldsymbol{\Sigma}_{h}, \boldsymbol{\theta}_{\mathbf{0}}, \mathbf{h}_{\mathbf{0}}$; to finally obtain the marginal likelihood.

Lastly, we also calculate the Bayes factor (BF_{ij}) that is defined as the ratio between the marginal likelihood of models i and j, $\frac{p(\mathbf{y}|M_i)}{p(\mathbf{y}|M_j)}$. Selected models will be those that maximize log marginal likelihood and those with lower Bayes factors in regard to the model with the highest marginal likelihood.

4 Results

4.1 Data

As in BBVA (2014), BCRP (2012), Consejo Fiscal (2018), MEF (2015), Rossini et al. (2011), Salinas and Chuquilín (2013) and Vtyurina and Leal (2016), we consider important to separate general government non-financial expenditure to distinguish effects of current and capital expenditure.

The vector of endogenous variables $\mathbf{y}_t$ includes the annual growth rate of export price index (IPX) and real annual growth rates of general government current expenditure (GC), general government capital expenditure (GK), gross domestic product (GDP) and central government tax revenue (TR). General government level data is important for expenditure variables due to the size of subnational spending while central government level data for revenues is enough because subnational tax revenue is very small. All variables are available in quarterly frequency in the Central Reserve Bank of Peru (BCRP) database from 1993Q1. GC, GK and TR series are deflated by Metropolitan Lima Price Index (IPC) in 2009 base, whereas GDP uses the 2007 base deflator. GC, GK, GDP and TR series are seasonally adjusted using the Census X-13 filter. For estimation purposes, the model considers data from 1995Q1 to 2018Q2.

Other variables where initially considered to be part of the baseline estimation but where ultimately dropped out to keep a small number of variables and a reasonable number of parameters. A monetary sector (inflation and interest rates) is not considered because preliminary results showed very small impact of monetary policy on GDP, as found in Ojeda and Rodríguez (2019). More external sector variables are not added because IPX parsimoniously summarizes external shocks to GDP and, according to Ganiko and Montoro (2018), explain most of fiscal revenue fluctuations. Other internal variables (such as consumer confidence) are not considered because GDP should already account for effects of these other variables.

Selected log-level variables are presented in Figure 1 and growth rate variables are presented in Figure 2. IPX exhibits a small decrease in the second half of the 90s and the beginning of the 2000s, associated to the Russian crisis and the dot-com bubble, and then from 2002 to 2008 shows a sustained growth, because of the boom in world business cycle until financial crisis in 2009 when IPX plummeted. Between 2010 and 2011 IPX picks up pace due to the recovery of USA and China but since 2012 IPX growth slowed down until 2017 when it started to increase again. GDP follows a dynamic similar to IPX due to the dependence to export prices. Despite sustained growth for most of the sample, GDP presents steep crisis in 1998, associated to El Niño phenomenon; 2001, coincident with internal political uncertainty; and 2009 due to the global financial crisis. Other important slowdowns occur in 2014, which could be associated to a fall in export prices; and 2017, explained by coastal El Niño.

Expenditure dynamics from the beginning of the sample up until 2009 could be classified as procyclical as mentioned in Mendoza and Melgarejo (2008). GC shows a strong increase in 1995 to then slowdown growth between 1996 and 2007, showing an important fall in 2001 in a context of crisis and government elections. GK on average exhibits negative growth rates until 2005, especially in 1998 and 2001; to then show a strong growth along with IPX and GDP growth. From 2008, GC continues stable growth with a few exceptions of fiscal consolidation episodes in 2008Q4, 2012Q1 and 2016Q4; and a countercyclical impulse at the second half of 2009. GK presents high growth rates between 2008 and 2010 because of a central government public investment impulse in 2009 and subnational investment increase in 2008 and 2010, after the beginning of the decentralization process. From 2011 onward, GK exhibits smaller growth rates with important contractions in 2011 and 2015 due to subnational authorities' election, and in 2016Q4 in a national government consolidation effort. Lastly, TR dynamic is close to IPX and GDP dynamics, showing important decreases in 1998-2001, 2009 and 2014-2017, beside tax reduction episodes in 2011 and 2015.

4.2 Identification Scheme

The structural model assumes a recursive identification scheme, so the order in which variables are estimated is important. Therefore, we consider the following ordering for the endogenous variable vector: $\mathbf{y}_t = (IPX_t, GC_t, GK_t, GDP_t, TR_t)'$. This ordering assumes that IPX doesn't have a contemporaneous response to other structural shocks. GC has a contemporaneous response only to IPX shocks while GK has a contemporaneous response to IPX and GC shocks. GDP can have a contemporaneous response to IPX, GC or GK shocks but not to TR shocks. Finally, TR responds contemporaneously to all structural shocks in the model.

The proposed ordering attempts to capture characteristics of the Peruvian macroeconomic and fiscal structure while delivering theoretically and empirically reasonable results. IPX is assumed to be the most exogenous variable, reflecting Peru's condition of small open economy. Even if GC and GK can respond to external demand shocks, it is assumed that expenditure variables do not contemporaneously react to GDP or TR shocks partially reflecting the fact that in Peru public budget is determined with anticipation and there aren't automatic stabilizers. Furthermore, GK can contemporaneously react to GC shocks capturing possible substitutability or complementarity between expenditure components. GDP can have a contemporaneous response to external or expenditure shocks, but not to tax shocks. Because of this, an impact multiplier for expenditure components can be calculated but tax revenue impact multipliers are assumed to be zero. Finally, the cyclicality of tax revenue to export prices and aggregate demand is captured permitting TR contemporaneously react to external and economic activity shocks. For the Robustness Analysis section, an alternative ordering is also proposed and discussed.

4.3 Evidence of Time-Varying Parameters

As in Bijsterbosch and Falagiarda (2015) and Guevara (2018), we present three statistics to test the hypothesis of time-varying parameters based on a fully fledged TVP-VAR-SV estimation. The first test is the trace test, as in Cogley and Sargent (2005), where the trace of the prior variance-covariance matrix is contrasted with posterior variance-covariance percentiles. The second test, the Kolmogorov-Smirnov test, contrasts if parameter distributions are the same in two different points of time. The third test, the t-test, contrasts if parameter means differ between two points of time. The results of these tests are shown in Table 1.

Trace test results favor a time-varying parameter model. Likewise, as found in Kolmogorov-Smirnov and t-tests, more than two thirds of the estimated parameters are found to be time-varying. These results apply to intercepts, contemporaneous parameters, lagged variable coefficients as well as stochastic volatilities. Nevertheless, it is also noted that not necessarily all parameters seem to be time-varying, especially those associated to lagged variables.

Furthermore, as Chan and Eisenstat (2018a), we plot estimated coefficients of a TVP-VAR-SV considering one lag. Figure 3 plots contemporaneous coefficients that determine GC, GK, GDP and TR equations; Figure 4 plots intercepts and coefficients associated with lagged variables; and Figure 5 plots stochastic volatilities. As with statistical tests, it is shown that contemporaneous parameters seem to change in time, especially those that determine GDP, GC and to a lesser extent TR. Regarding intercepts and coefficients associated to lagged variables, only the former exhibit a marked variability.

About volatility, we also have graphic evidence for time-varying dynamics. IPX volatility is increased during the global financial crisis and GDP volatility displays an important reduction in the last 20 years, consistent with greater macroeconomic stability due to low inflation and sustained economic growth. GC and GK volatilities differ. GC volatility exhibits a downward trend from the beginning of the sample until 2010 from where it increases for the 2011-2016 government, whereas GK volatility exhibits peaks around 2000, 2011 and 2017 coincident with sudden changes in public investment execution. Finally, TR volatility exhibits peaks at the beginning of the sample, associated to tax simplification measures; at the middle of the sample, associated to an extraordinary increase in export prices; and at the end of the sample, associated to tax policy measures in 2015 and a reduction in international export prices.

4.4 Model Selection

Log marginal likelihood and Bayes factor are estimated as criteria to select between 32 models. Model 1 is denoted by 11111 because it assumes that all equations in the model are time-varying (TVP-VAR-SV), whereas Model 32 is denoted by 00000 because it assumes that none of the equations are time-varying (CVAR-SV). The 30 remaining models are hybrid because they assume that at least one equation has constant parameters. For instance, Model 2 is denoted by 01111 because it indicates that the first equation of the model has constant parameters while the other four equations have time-varying parameters. Our results are presented in Table 2.

Log marginal likelihood indicates that the preferred model should be Model 1, where it is considered that all equations have time-varying parameters. However, Model 3, where the equation that determines GC is constant; Model 5, where the equation that determines GDP is constant; and Model 12 where both GC and GDP equations are constant; all have a log marginal likelihood very close to Model 1 which is reflected by a Bayes factor close to one. Other models that also have a log marginal likelihood close to the preferred model and small Bayes factors (smaller than four) are Model 4, where GK equation is constant; Model 9, where IPX and GDP equations are constant; and Model 14 where GK and GDP equations are constant.

Models where most parameters are time-varying are preferred over a constant model. Models where 3 or more equations are assumed to be constant have a significantly lower log marginal likelihood and high Bayes factors. However, there isn't a clear preference for a completely time-varying model over models where one or two equations are constant, especially those that determine GDP and GC. Consequently, for next sections we focus on models 1, 3, 5 and 12; those with higher log marginal likelihood and Bayes factors closer to one.

The aforementioned result is important because models 5 and 12, where GDP equation is assumed to be constant, imply more stable fiscal multipliers across time. In that case, fiscal policy capacity would be mainly explained by the instrument used, expenditure or revenue, and its composition, GC or GK.

4.5 Impulse Response Functions

Figure 6 presents impulse response functions (IRF) of GDP to GC, GK and TR shocks across each quarter between 1995Q1 and 2018Q2. This exercise is done for each of the four selected models (1,3,5,12) and for a response horizon of 20 quarters.

Regarding GC shocks, we find a positive impact on GDP for all models and all periods of time. However, we find that dynamics of models 1 and 3 differ from dynamics of models 5 and 12. For models 1 and 3 we find that until 2000, impact of a GC shocks is smaller than in 2000-2013, which could be explained by a still procyclical fiscal policy in the 90s as mentioned by Mendoza and Melgarejo (2008) and as seen graphically in the GC growth plot. During 2000-2013 we also find some peaks in GDP response around 2001, 2007-2008 and 2012-2013; where the first two can be associated to economic crises and the third one, with a lead, to economic slowdown. For 2013-2018, GDP exhibits a smaller response that could be associated to less efficient current expenditure after a fast pace growth in 2013 and 2015. In contrast, in models 5 and 12, where GDP equation is constant, we find that after a smaller impact during the 90s GC shocks have a growing impact on GDP until the end of the sample. This result is consistent with more sound macroeconomic stability and lower public indebtment as mentioned in Mendoza and Melgarejo (2008).

Regarding GK shocks, we also find a positive impact on GDP in the four models and throughout the whole sample. However, models 1 and 3 also exhibit a different dynamic than models 5 and 12. In models 1 and 3, GDP's smaller response to GK shocks in the 90s could be explained by GK adjustment to lower tax revenues as documented by Santa María et al. (2009). From the 2000s onward, the impact of GK shocks has an upward trend and exhibits peaks like GC shocks in 2001, 2007-2008 and 2012-2013, and at the end of the sample when the occurrence of a coastal El Niño caused the destruction of physical capital. In contrast, models 5 and 12 exhibit a less fluctuating and more pronounced growth of GDP's response to GK shocks due to a constant GDP equation. In spite of this less fluctuating response due to a constant equation, we find that during 2009-2012 and 2017-2018 GK shocks have a greater impact. The increase in 2009-2012 could be explained by a more persistent effect of the global financial crisis and by sudden changes in subnational public investment as shown in Jiménez et al. (2018); whereas the increase in 2017-2018 could be related to a higher impact of public investment after a coastal El Niño.

For TR shocks, GDP's response changes in sign and size according to the model used. For models 1 and 3 we find that in short-run horizons GDP has a negative response in the first half of the sample and a positive response on the second half of the sample. A positive response of GDP also occurs in Guevara (2018) and could be explained by higher tax noncompliance as shown in MEF (2019) or, as mentioned in Lahura and Castillo (2018), because TR series capture GDP dynamics instead of tax policy stance. We also find that in 2008-2009 there is a more negative medium-term response of GDP to TR shocks which could be explained by a crisis context. In models 5 and 12 we find that GDP response to TR shocks is negative for all the estimation sample. When a constant GDP equation is assumed, size of TR shocks impact is similar in every quarter; nevertheless, this impact might have a small downward trend, especially in Model 12.

Figure 7 presents the median response for all the sample of GDP to GC, GK and TR shocks and the four selected models. Percentiles 16 and 84 are presented, and for comparison the mean response of a CVAR-SV (Model 32) is also presented. As in Figure 5, it can be seen that GC shocks have positive effects on GDP for a twenty quarter horizon; however, these effects are within the confidence bounds only for four quarters in models 1 and 3 and five or six quarters in models 5 and 12. Additionally, we find that for one or two quarters the response of GDP to GC shocks is similar to a CVAR-SV, but after those quarters CVAR-SV overestimates the response of GDP being even higher than confidence bounds in models 1, 3 and 5.

Median response of GDP to GK shocks is also positive for all the sample and the four selected models. Percentiles 16 and 84 are positive for six quarters in models 1 and 3, and for ten quarters in models 5 and 12. As mentioned in Salinas and Chiquilín (2013), this result reflects higher persistency in the impact of public investment relative to current expenditure. Additionally, we find that the response of GDP to GK shocks is underestimated in a CVAR-SV in the first quarter and overestimated in the next quarters, being over the confidence bounds after eight quarters in models 1, 3 and 5. As with GC shocks, the response of GDP to GK shocks is kept within confidence bounds of model 12 because there are two constant equations, GC and GDP.

Because of identification assumptions, median response of GDP to TR shocks is zero in the first quarter, and maintains a similar value in the second quarter for models 1 and 3. In longer horizons, median response turns negative for those models, but confidence bounds can take positive values as evidenced for the second half of the sample in Figure 5. In models 5 and 12, the median response of GDP to a TR shock is negative in every quarter after the first and its confidence bounds are positive for at least ten quarters. As with GC and GK shocks, GDP response is overestimated in the CVAR-SV model, being higher than confidence bounds in models 1, 3 and 5.

Figure 8 presents the median response of GDP to GC, GK and TR shocks for the four estimated models in three specific points of time: 1996Q1, 2007Q4 and 2017Q2. Regarding GC shocks, the response of GDP is positive in the three analyzed periods and all selected models. In models 1 and 3 we find that GDP response to a GC shock is similar in 1996Q1 and 2017Q4, but higher in 2007Q4 due to the proximity to the financial crisis. In models 5 and 12, for horizons up to six quarters, we find that GC has a bigger impact on GDP in 2017Q2. This result could be explained by an increase in expenditure impact due to lower public debt and greater macroeconomic stability. For horizons greater than six quarters, we find that response of GDP is similar in the three points of time for Model 5 but is smaller in 2017Q2 for Model 12.

Regarding GK shocks, as in Figures 6 and Figure 7, we find that the response of GDP is positive for the three points of time and for all selected models. For one and two quarters, models 1 and 3 exhibit a greater response of GDP during 2007Q4 and 2017Q2 associated to a higher impact of public investment before the global financial crisis and after coastal El Niño. For longer horizons we find that the response of GDP is greater in 2007Q4 and smaller in 1996Q1, associated to a more procyclical dynamic in the 90s. In models 5 and 12 there are similar results. For horizons smaller than four quarters we find that GK shocks have a higher impact in 2017Q2 and 2007Q4, and a smaller impact in 1996Q1. For a longer horizon, the response of GDP to GK shocks is smaller in 2017Q2 than in 1996Q1 and 2007Q4.

Finally, for TR shocks in models 1 and 3 we find a negative response of GDP in 1996Q1 and 2007Q4, whereas in 2017Q4 we find a positive response that peaks in two or three quarters. In 1996Q1 the response of GDP reaches its lowest point around three or four quarters and in 2007Q4 around five or six quarters, timing with the global financial crisis and an income tax reduction identified in Lahura and Castillo (2018). In models 5 and 12, the response of GDP to a TR shock is negative in the three points of time under analysis, reaching its lowest value around four and five quarters. We also find that for longer horizons the size of GDP response is smaller in 2017Q2, which could indicate a deterioration of tax policy as a countercyclical tool.

From this subsection we can conclude that over time and all estimated models, GC and GK shocks have a positive impact over GDP, consistent with other authors findings. However, dynamics of these results can differ if we compare models 1 and 3 with models 5 and 12. The former models favor the hypothesis of a stronger fiscal policy during recession, whereas the latter are more consistent with a positive trend in fiscal policy strength due to sustainable public finances and macroeconomic soundness, especially for GK. The same can't be said for TR shocks. A consistently negative impact of TR shocks is only obtained in models 5 and 12, giving more empirical support to study tax policy through models where a constant GDP equation is imposed.

4.6 Forecast Error Variance Decomposition

Figure 9 presents the twenty-quarter forecast error variance decomposition (FEVD) of GDP for the selected models across 1995Q1 and 2018Q2. FEVD of GDP can be decomposed according to the uncertainty of five shocks: international export prices shocks (EX), GC shocks, GK shocks, aggregate demand shocks (AD), and TR shocks.

Until the beginning of the 2000s, we find that in all models around 70% of the FEVD of GDP is explained by GC and GK shocks, due to very volatile growth rates in a context of structural changes during the 90s. In models 1 and 3, the contribution of GC and GK shocks is similar (around 35% each) whereas in models 5 and 12, the contribution of GK is bigger (around 50%) giving more weight to the negative growth rates seen in the 90s. The remaining 30% is explained mainly by AD and EX shocks, with a similar contribution in all models. TR shocks have a small contribution to FEVD of GDP, being smaller than 1%.

For the 2000s we find an important increase in EX shocks contribution to FEVD of GDP for all models, passing from 10% to close to 60%. This increase would be explained by a higher volatility in external variables before and after the global financial crisis, as evidenced in other works as Ojeda and Rodriguez (2019). For this period, contribution of GC and GK shocks is reduced to 40%, especially for GK shocks in models 1 and 3 (around 10%), while the contribution of AD shocks is close to 1% and the contribution of TR shocks close to zero.

Finally, from 2010 to 2018, unlike Ojeda and Rodriguez (2019), all models show that EX shocks contribution to GDP FEVD is reduced to 10% in models 1 and 3 and 20% in models 5 and 12 because of less uncertain financial stability compared to previous years. In contrast, GC and GK shocks have a bigger weight toward the end of the sample being higher than 80% in models 1 and 3, and 70% in models 5 and 12. In models 1 and 3, the highest contribution comes from GC shocks (more than 50%) because of volatile increase in current expenditure during the 2011-2016 government and fiscal consolidation efforts in 2016-2017; whereas in models 5 and 12, the highest contribution comes from GK shocks (around 40%) because of the rise and fall of subnational public investment (2010-2011 and 2014-2015) and the depletion of natural resourced fueled financing, both documented in Jiménez et al. (2018), beside an important public expenditure cut in 2016Q4. Lastly, the contribution of AD shocks is small (around 2%) and the contribution of TR is zero, reflecting reduced capacity of TR to impact GDP.

Results of this subsection indicate that GDP's FEVD dynamic is time-varying and consistent in all models. During the international financial crisis, most of GDP's uncertainty is explained by global uncertainty, whereas before and after the crises, GC and GK shocks are the most important.

AD shocks have a small impact on FEVD, and TR shocks contribution is in practice zero. These results reflect the difficulty to anticipate movements not only of external shocks but also the two components of government expenditure which are of discretional nature. In contrast, internal demand shocks are more predictable in a context of stable and sustained growth, and tax policy impact is small in a context where structural tax reforms occurred before the estimation window.

4.7 Historical Decomposition

Figure 10 presents historical decomposition of GDP to EX, GC, GK, AD and TR shocks for all models under analysis using the approach of Wong (2017). We find that beside EX and AD shocks; GC, GK, and to a less extent, TR shocks have important contributions to GDP dynamics throughout the whole timespan. These results are similar across selected models being a little more pronounced in models 5 and 12 due to a constant GDP equation.

Until the beginning of the 2000s, AD shocks have a negative contribution to GDP growth rates (especially in models 5 and 12) except for 1997, of higher economic growth. Negative contributions between 1998 and the beginning of the 2000s can be explained by an extraordinary El Niño and internal political tensions in 2000-2001. For the same period, EX shocks also had a negative contribution since 1997 with the Asian financial crisis and up until 2001 with the dot-com bubble. GK shocks also have negative contributions, especially in models 3, 5 and 12, that could be explained by less GK expenditure to compensate higher GC expenditure and less tax revenues as documented by Santa María et al. (2009). In contrast, GC shocks contribution is markedly positive, especially in models 5 and 12, due to a stronger rigidity in this type of expenditure and remunerative increases during the second half of the 90s. In spite of multiple tax reforms identified in Lahura and Castillo (2018), the contribution of TR shocks until the first years of the 2000s was negative but small in all models.

From 2002 to 2006, AD and EX shocks have strong positive contributions in models 5 and 12 in a context of domestic demand expansion and world economic boom, contrary to GC and GK shocks which show negative contributions in a context where, according to Jiménez et al. (2018), decentralization process transferred expense competencies to local and regional government with less capacities than the central government. TR shocks have a positive but small contribution to GDP despite some tax measures documented by Lahura and Castillo (2018).

For 2007-2012, all models show a markedly positive contribution of EX shocks in 2007 and 2008 that turns strongly negative in 2009, because of the global financial crisis, and then retakes positive values in 2010-2012, associated to a fast recovery in China. It is also shown that AD shocks have negative but small contributions in 2009 that turn positive for other years reflecting some degree of internal demand support. Regarding expenditure shocks, we find that GC shocks have a positive contribution in 2007-2008, whereas GK shocks have a more persistent effect throughout 2007-2012. GC shocks' positive contribution is explained by a first impulse of current expenditure that should latter be reverted in a fiscal consolidation process planned in MEF (2008 and 2011). On the other hand, GK shocks' positive contribution is explained by an increase in subnational investment in 2008 and 2012, and by a fiscal stimulus plan from the government between 2009 and 2011. In 2009, we also have a positive contribution of TR, especially in models 5 and 12, which, as documented by Lahura and Castillo (2018), could be associated to an exogenous income tax reduction. For this particular episode, we can say that fiscal shocks countered the negative contribution of external shocks.

For 2012-2016, it is shown that positive contribution of EX shocks seen previous years become negative due to a slow global recovery and AD shocks also have negative contributions between 2014 and 2015 in a context of internal economic slowdown. In contrast, GC shocks have a positive contribution, especially marked in models 5 and 12, whereas GK shocks have a negative contribution in models 1 and 3 associated to lower public investment from both subnational and national level, especially in 2016Q4. Again, even in presence of tax measures identified in Ganiko and Merino (2018) to specifically reactivate economic activity, the contribution of TR shocks is found to be small.

Lastly, for 2017-2018, we find that EX shocks have a null contribution in all models as a sign of the end of sluggish world growth. Even if AD shocks have a positive contribution at the beginning of 2017, in models 1, 3 and 5 we find that AD shocks have a negative contribution since the second half of 2017 associated to a coastal El Niño. Regarding expenditure shocks, for GC shocks we find a negative contribution until the end of 2017 (especially in models 5 and 12) associated to fiscal a consolidation effort documented in MEF (2017) while for GK shocks we find a contribution close to zero. Models 5 and 12 also evidence a positive contribution of TR that could be associated to tax measures established in 2016, detailed in Ganiko and Merino (2018), aimed to tackle economic slowdown and encourage formalization.

Throughout this subsection, it is evident that economic growth in Peru is dependent to the international context, being the most important shock in the proximity to the global financial crisis in all analyzed models. However, it is also important to note that internal factors such as AD, GC and GK shocks are determinant of GDP fluctuations, being the most important factors in the second half of the 90s and being as important as EX shocks in the aftermath of the global crisis. As evidenced in 2009, GC and GK shocks have the potential to be effective countercyclical tools in adverse scenarios. The same cannot be said for TR shocks due to their reduced impact in all models, being relatively important only in 2009 for models 5 and 12.

4.8 Fiscal Multipliers

As IRFs show the response of endogenous variables to exogeneous fiscal shocks, they can be used as input to obtain fiscal multipliers for GC, GK and TR in each point of time. Specifically, we use the next equation:

$$m_{t,H} = \frac{\sum_{h=1}^{H} y_{t+h}}{\sum_{h=1}^{H} g_{t+h}} \times \frac{\bar{Y}}{\bar{G}}, \tag{13}$$

where $m_{t,H}$ is the fiscal multiplier in period t at H horizons, y_{t+h} is the response of GDP to a fiscal shock in period $t+h$, g_{t+h} is the response of a fiscal variable to a shock to itself in period $t+h$, and $\frac{\bar{Y}}{\bar{G}}$ is the inverse of the average ratio between the fiscal variable and GDP for all the time span.

It is worth noting that when $H = 0$, we have the impact or contemporaneous multiplier; when $H = 3$, we have the one-year multiplier; and when $H = 19$, we have the five year or medium-term multiplier. As fiscal multipliers are calculated using 10 000 simulations of each of the preferred models, we can calculate confidence bounds using percentiles 16 and 84. Figure 11 presents our results on one-year multipliers, the most commonly reported. More graphical detail on impact and medium-term multipliers is available upon request.

Regarding GC impact multipliers, we find positive values between 0.2 and 0.4 Soles depending on the selected model. Models 1 and 3 present temporal increases in 2001, 2009 and 2013 reaching up to 0.35 Soles during the global financial crisis. In models 5 and 12, sudden increases aren't found; however, there is a marked upward trend from a minimum of 0.25 Soles before the 2000s to 0.40 Soles in 2018.

For GK impact multiplier, we find higher values between 0.50 and more than 1.50 Soles, depending on the model and moment of time. In models 1 and 3 we also find temporal increases in 2001, 2009, 2013 and 2018 reflecting higher impact close to economic crises. In models 5 and 12 we find that GK shocks' impact follows an upward trend rather than a cyclical dynamic. In spite of a slight increase between 2008 and 2012, it is important to mention that impact multiplier for GK passes from 0.50 Soles at the beginning of the sample to more than 1 Sol towards the end.

TR impact multiplier is assumed to be zero in all models due to the identification scheme detailed in previous sections.

As mentioned before, Figure 11 presents one-year multipliers. Regarding GC multipliers we find values between 0.25 and 0.75 Soles. In models 1 and 3 we still find an increase around economic crises, albeit a little smaller, peaking at 0.35 Soles. In models 5 and 12, we still find an upward trend going from 0.50 to 0.75 Soles. This last result is similar to what Mendoza and Melgarejo (2008) find when they compare the impact of expenditure on 1980-1990 with 1990-2006.

Regarding GK one-year multipliers, we also find higher values between 0.5 and 1.1 Soles. In models 1 and 3, the increase found around economic crises is kept adding between 0.10 and 0.20 Soles, a smaller increase than what is found by other authors like BCRP (2012) and Sanchez and Galindo (2013). In all models, a growing GK multiplier is exhibited, going from 0.5 to 1 Sol in models 1 and 3, and from 0.7 to more than 1 Sol in models 5 and 12. As with GC multipliers, the increase of GK multipliers is similar to what's found in Mendoza and Melgarejo (2008), which could be explained by solvent public finances due to a more prudent fiscal policy in latest years.

Regarding TR one-year multipliers, we find a sign change in models 1 and 3. In these models, we find negative values not lower than -0.10 Soles for 1995-2000 and after that multipliers reach zero around 2010. From there on, TR multipliers take positive values as in Guevara (2018). However, in both models 1 and 3, confidence bounds take positive and negative values in all the estimation sample indicating we cannot reject a multiplier equal to zero for TR. In contrast, models 5 and 12 exhibit negative and stable one-year multipliers for TR between -0.10 and -0.15 with confidence bounds always below zero. This result is similar to Rossini et al. (2012), Sánchez and Galindo (2013), BBVA (2014) and Consejo Fiscal (2018); who find small but significant negative TR multipliers.

On medium-term multipliers, for GC in models 1 and 3 we find results similar to impact and one-year multipliers regarding dynamics and size. However, we find that for models in 2010-2018 confidence bounds widen up, possibly indicating that in the medium-term GC is less effective as mentioned by Vyturina and Leal (2016). In contrast, in models 5 and 12 we find more stable GC multipliers around 0.75 Soles with strictly positive confidence bounds, similar to what is found by Consejo Fiscal (2018).

In the medium-term, GK multipliers exhibit the same increases as impact and one-year multipliers in models 1 and 3; however, only the former exhibits an upward trend from 0.6 to over 1 Sol. On the other hand, models 5 and 12 exhibit more stable medium-term multipliers close to 1 Sol, with confidence bounds strictly higher than 0.5 Soles.

Lastly, in the medium-term, TR multipliers take values that could be considered zero in all models and every quarter. Confidence bounds take extreme values between -1 and 2 Soles, being especially wide for models 5 and 12. This result indicates that unlike GC and to greater extent GK, TR shocks do not have permanent effects on economic activity in none of the preferred models nor in any point of time.

About fiscal multipliers we can highlight two important results. First of all, GC and GK multipliers are found to be strictly positive within a year, as most of the applied papers for Peru, but also time-varying; in part because of business cycles in models 1 and 3, and due to a trend in fiscal strength in models 5 and 12. In second place, TR multipliers are found to be non-significant in models 1 and 3, whereas in models 5 and 12 one-year multipliers are found to be small and negative but significant and stable. These two results imply that fiscal policy studies in Peru require GC and GK fiscal multipliers to be constantly updated. At the time of writing, GC and GK multipliers take values between 0.30-0.70 Soles and 1.00-1.15 Soles, notably higher than their value in the 90s between 0.25-0.50 Soles and 0.50-0.65 Soles, respectively. It is also worth noting that even if there might be higher multipliers during recessions, the increase is found to be smaller than the considered by other authors, around 0.10 and 0.20 Soles. Finally, for TR multipliers in Peru we can suggest conservative values between -0.10 and -0.15 Soles for all the estimation sample.

These results imply that expenditure driven fiscal policy strength has increased over time in Peru, especially through capital expenditure. Because of that, we emphasize that countercyclical fiscal policy in following years should be mostly driven by capital expenditure, of which impact is the highest to date. Due to limited impact on GDP, tax revenue could be used to finance expansionary fiscal policy.

4.9 Policy Application

A common practice for policymakers in Peru is to separate fiscal impulse in expenditure and revenues to give them weights according to fiscal multipliers in order to have a quick estimate to answer if fiscal policy had a positive or negative effect on aggregate demand. This exercise is reported by BCRP in their Reporte de Inflación and is also done by the Fiscal Council (CF). More detail on the fiscal impulse indicator can be seen in Blanchard (1990), Gramlich (1990), Chouraqui et al. (1990) and Schinasi and Lutz (1991); whereas more detail on the implementation for Peru can be seen in Secretaría Técnica del Consejo Fiscal (2018).

Using annual average fiscal multipliers of the four estimated models in previous sections and the official methodology for structural accounts according to MEF (2016) for the fiscal impulse, we do a similar exercise to the one made by BCRP and CF for the 2009-2018 window as detailed in the next equation:

$$Fiscal\_impact_t = \sum_{i}^{t} M_{i,t} FI_{i,t}. \tag{14}$$

where fiscal impact in time t corresponds to the average fiscal multiplier $M_{i,t}$ according to the H-TVP-VAR-SV methodology of fiscal policy instrument i in the year t, and $FI_{i,t}$ corresponds to the fiscal impulse of instrument i in year t according to MEF (2016) methodology. Results of our exercise are presented in Figure 12 where we contrast with results of BCRP and CF.

Regarding sign of impact, we find no differences between BCRP, CF and this document. However, there are some differences on the impact size according to the set of multipliers assumed. In years 2011, 2013, 2014 and 2015, the application of this document works as a weighted average between BCRP and CF, who assume a multiplier in expansion and recession or the same multiplier across time. In the same manner, the impact found in 2016-2018 is higher in our application due to higher GC and GK multipliers towards the end of the sample.

Results from this section are important because they show that our findings are useful for policymakers. Real-time estimation of fiscal multipliers fine-tunes the quantification of fiscal policy's impact on GDP in a context where static and regime determined fiscal multipliers can be outdated or output gap is close to zero. Hence, continuous revision of assumed fiscal multipliers is an important practice to precise macroeconomic impact of different fiscal scenarios or give support to policy decisions in following years.

4.10 Other Results

Other results from our estimations can be of interest and their graphical detail is available upon request. First of all, we find that on average EX shocks have positive effects on GDP, consistent with Peru's dependency on global demand, albeit with a higher and more significant impact in models 5 and 12. The dynamics of this result indicate that impact size has grown since the beginning of the sample reaching a peak in 2009. After that, this value decreases until 2013 and from that moment, the impact of EX shocks become negative in models 1 and 3, unlike Ojeda and Rodriguez (2019), and stabilizes in positive values in models 5 and 12, giving more empirical support to models where GDP equation is restricted.

In second place, we find that on average TR has a positive response to both EX and AD shocks. Regarding EX shocks, we find that TR response is similar across models reaching a peak around three or four quarters, whereas for AD shocks we find a more significant response in models 1 and 3 after also reaching a peak around three or four quarters. We also find that dynamics of TR response to EX shocks is time-varying, reaching its highest value around global financial crisis and then decreasing to still positive values, higher in models 5 and 12 as a reflex of high export price dependency in the last years. Regarding TR response dynamics to AD shocks, we find that impact has grown in the last decade across all models highlighting the importance of internal demand for tax revenue.

About TR we can additionally evaluate FEVD and HD across time. FEVD shows the importance of EX shocks uncertainty on TR, especially around the global financial crisis as with GDP FEVD. In contrast, AD shocks have small impacts until 2009 and zero thereafter, being GC and GK shocks more relevant. TR's own uncertainty has an important contribution to its FEVD and is associated to uncertainty around a set of individual tax measures executed in all the estimation sample.

For HD we find that the most important driver of TR fluctuations are EX shocks, again highlighting that international prices are the main determinants of tax revenues in all the estimation period. Internal factors, especially GC, GK and to a less extent AD shocks, also have important contributions, being higher in models 5 and 12. Unlike GDP HD, TR shocks have significant effects on TR dynamics. This last result is important because it notes that tax policy measures that have small impact on GDP can have high impact on TR.

Results from this section are important not only because they are consistent with external shocks literature and tax revenue determinants in Peru, but also because they can be seen as a starting point for future research agenda in these topics. Furthermore, these results give greater support to models 5 and 12, at least for TR related research. For more detail on external shocks and tax revenue determinants literature in Peru, Ojeda and Rodríguez (2019) and Lahura and Castillo (2018) are suggested.

5 Robustness Analysis

To validate our baseline results, we present five robustness exercises: (i) change in priors; (ii) alternative ordering (IPX, TR, GC, GK, GDP); (iii) change in lag structure ($p = 2$); (iv) using non-primary GDP as domestic demand variable; and (v) using another index (S&P GSCI) to capture export prices. Graphical details on these exercises is also available upon request.

Baseline estimations from previous sections used the same priors as Chan and Eisenstat (2018a) which are non-informative. Because of that, our first robustness exercise is to evaluate the sensitivity of our results to a prior that uses least square estimates like Primiceri (2005) for a training sample between 1990 and 2006, the same subsample considered by Mendoza and Melgarejo (2008). To do so, we expand our sample to 1990 using an own IPX index. We find that results for GC and GK shocks are mostly unaltered in IRF, FEVD, HD and one-year multipliers; however, for TR shocks we find different results. With a different prior, TR shocks could have a positive effect on GDP on the whole sample in models 1 and 3. Likewise, for those models, TR one-year multipliers never take negative values as found by other authors and in baseline estimations.

The second robustness exercise uses a different ordering than the considered in baseline estimations in which TR is ordered second after IPX. The idea behind this ordering is straightforward, an increase in IPX directly increases TR, which at the same time fuel up GC and GK expenditure in such a way that now all variables can affect GDP contemporaneously. As shown in IRF, cyclicity of GC and GK shocks is more pronounced, but on average the impact over GDP is still positive. In contrast, GDP's response to a TR shock is positive in all models. Regarding FEVD and HD there aren't many differences, however, GC and GK one-year multipliers lose some significance at the end of the sample and TR multipliers are significantly possible in most of the sample. This exercise highlights the importance of identification assumptions to evaluate TR shocks. We find that the existence of a negative response of GDP to TR shocks depends on a contemporaneous response of TR to GDP shocks, which is considered in our baseline estimations and in methodologies like Blanchard and Perotti (2002) .

The third robustness exercise consists in changing the number of lags used in estimation. Using two lags as alternative specification, we find that our results are similar regarding FEVD and HD. As shown in IRF, we find that results both cyclical impact of expenditure shocks in models 1 and 3 and growing fiscal strength in models 5 and 12 are kept. Unlike baseline estimations there seems to be a negative impact of TR shocks over GDP for the whole sample; however, this effect also seems to be non-significant. Regarding one-year fiscal multipliers, for GC and GK we find similar values to the baseline estimations albeit with lower significance at the end of the sample in models 1 and 3. For TR multipliers, we find negative values for all models across all the sample but with low significance in models 1 and 3.

The fourth robustness analysis uses non-primary GDP as an indicator of economic activity more related to internal demand because it doesn't consider sectors as mining or industrial fishing. Repeatedly, our main results on FEVD, HD and even IRF don't change when compared to baseline estimations. The only difference worth noticing is that there seems to be a steeper growth in the impact of GC and GK shocks at the end of the sample. Hence, for one-year multipliers of GC and GK, an upward trend is exhibited in all models, especially in the last part of the sample. TR multipliers are similar to baseline estimations, being non-significant in models 1 and 3, and negative and stable in models 5 and 12.

The fifth and last robustness exercise consists in changing IPX with another external variable like Standard & Poor's Goldman Sachs Commodity Index (S&P GSCI) used by Guevara (2018) and Ojeda and Rodríguez (2019). We find that our results for HD and IRF for GC and GK shocks are kept unchanged. Nevertheless, we find that GDP's FEVD gives greater relevance to external shocks in the second half of the 90s, which could be explained by higher uncertainty in the international context given the Asian and Russian crises. On TR shocks we find a positive non-significant impact in models 1 and 3. In that way, multipliers for GC and GK are similar to baseline results, whereas TR multipliers are only similar in models 5 and 12.

This section shows that most of our results are unchanged under many assumption changes. FEVD and HD of GDP is similar in all robustness exercises, which reaffirms the importance of EX shocks around global financial crisis and fiscal expenditure shocks in the rest of the sample. Regarding IRF and one-year fiscal multipliers, we find consistent results for GC and GK but not for TR shocks. We find that TR shocks impact depends not only in model and time, but also in prior and identification scheme. Nevertheless, we still find that for all robustness exercises except for the identification scheme, TR multipliers take small negative and stable values close to -0.10 Soles in models 5 and 12. This last result allows us to say that TR multipliers are close to zero in a context where its dynamics are mainly determined by IPX and GDP. Estimation of specific tax policy multipliers is still an open topic in research agenda to evaluate big tax reforms and particular tax policy measures.

6 Conclusions

Estimations for the Peruvian case indicate that most equations that associate fiscal policy with macroeconomic activity are time-varying. Because of that, strength and impact of fiscal policy tools can change over time, discarding the use of completely constant models. However, hybrid models in which the equation that determines GDP is constant cannot be discarded. This result implies that time-varying sensitivity of GDP to fiscal shocks might be limited to sluggish changes.

Most fiscal shocks have the expected impact on GDP. Current expenditure (GC) and capital expenditure (GK) shocks have a positive impact on GDP, whereas tax revenue (TR) shocks have a negative impact. However, TR shocks don't always have a significant negative sign in completely time-varying models, giving more empirical support to hybrid models for tax revenue analysis.

During the global financial crisis of 2009, the most important determinant of GDP uncertainty is external (EX) shocks. However, in other periods, GC and GK shocks have a more important role. This result implies that uncertainty on public expenditure variables, of unpredictable and discretional nature, is transferred directly to GDP uncertainty. In contrast, TR uncertainty, highly dependent on EX and aggregate demand (AD) shocks, doesn't have a meaningful impact.

Through historical decomposition, we associate contributions of different shocks to GDP growth with specific episodes in macroeconomic and fiscal history. In particular, we find that the negative impact of the global financial crisis during 2008-2009 was partially offset by GK shocks and, to a lesser extent, TR shocks. Other episodes where fiscal shocks (mostly GK and GC) have an important contribution occur around 2000, when GK had strong reductions; and in 2013-2015, when GC had a strong impulse. With these results, we cannot conclude that most of GDP's fluctuations are necessarily attributed to EX shocks.

During 1996-2018, GK multipliers are higher than GC's, and the latter are in absolute value higher than TR's as found by other authors. However, unlike other authors, we find that GK and, to a lesser extent, GC multipliers have increased in the last 20 years. This result reflects an improvement of expenditure driven fiscal policy strength consistent with years of prudent fiscal policy. Additionally, these results are proven to be consistent across all our robustness exercises.

We also find that in models where GDP equation is not restricted to be constant, slower economic growth is associated with higher GC and GK multipliers, albeit with a lower increase than what is found by other papers for Peru, giving small support for business cycle driven expenditure multipliers. In contrast, TR multiplier is significant only in models where GDP equation is constant, resulting in stable and small TR multipliers. This result occurs in a context where big tax reforms haven't occurred in the estimation sample and TR is mostly driven by EX and AD shocks. Calculating specific structural tax policy multipliers is part of the research agenda as well as incorporating new data, more efficient estimation methods and other identification schemes.

Finally, as shown in our policy application, impact of fiscal policy estimation and multiplier calculation should be constantly updated. We can conclude that fiscal policy's capacity to impact GDP through expenditure in Peru has strengthened over time, especially by capital expenditure, to a maximum at the time of writing. Therefore, now more than ever, countercyclical fiscal policies should be mainly driven by public investment.

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Table 1. Time Varying Tests for Coefficients and Volatility

5 Variables Model						
Trace Test			Kolmogorov-Smirnov		t-test	
Trace	0.0395		1996Q1-2006Q4	2006Q4-2017Q2	1996Q1-2006Q4	2006Q4-2017Q2
16%	0.3877	$a_{i,j,t}$	10/10	9/10	9/10	10/10
50%	0.7972	$b_{i,t}, b_{i,j,t}$	24/30	27/30	24/30	27/30
84%	1.7274	$h_{i,t}$	4/5	5/5	4/5	5/5

The Trace test is reported in the first column. The test compares the trace from the prior variance covariance matrix with the 16%, 50% and 84% percentiles of the posterior variance covariance matrix; if the trace is significantly smaller than these percentiles, there is evidence for time varying parameters. The Kolmogorov-Smirnov test is reported in the second column and tests the null hypothesis that two distributions come from the same continuous distribution. The t-test tests the null hypothesis that two distributions have equal mean and is reported in third column. For both the Kolmogorov-Smirnov and t-test, we report the number of parameters which reject the null hypothesis at the 1% significance level comparing parameters in the 1996Q1 with 2006Q4 and 2006Q4 with 2017Q2.

Table 2. Model Comparison

Model		Equation					Criteria	
N°	Name	IPX	GC	GK	GDP	TR	ML	BF
1	**TVP-VAR-SV (0)**	**1**	**1**	**1**	**1**	**1**	**-1583.6**	**1.0**
2	H-TVP-VAR-SV (1)	0	1	1	1	1	-1585.2	5.0
3	**H-TVP-VAR-SV (1)**	**1**	**0**	**1**	**1**	**1**	**-1584.0**	**1.5**
4	H-TVP-VAR-SV (1)	1	1	0	1	1	-1584.6	2.8
5	**H-TVP-VAR-SV (1)**	**1**	**1**	**1**	**0**	**1**	**-1583.8**	**1.2**
6	H-TVP-VAR-SV (1)	1	1	1	1	0	-1586.7	21.2
7	H-TVP-VAR-SV (2)	0	0	1	1	1	-1585.2	4.6
8	H-TVP-VAR-SV (2)	0	1	0	1	1	-1585.6	7.3
9	H-TVP-VAR-SV (2)	0	1	1	0	1	-1584.5	2.3
10	H-TVP-VAR-SV (2)	0	1	1	1	0	-1587.7	61.3
11	H-TVP-VAR-SV (2)	1	0	0	1	1	-1584.7	3.1
12	**H-TVP-VAR-SV (2)**	**1**	**0**	**1**	**0**	**1**	**-1584.0**	**1.4**
13	H-TVP-VAR-SV (2)	1	0	1	1	0	-1587.0	30.4
14	H-TVP-VAR-SV (2)	1	1	0	0	1	-1584.6	2.8
15	H-TVP-VAR-SV (2)	1	1	0	1	0	-1587.6	55.5
16	H-TVP-VAR-SV (2)	1	1	1	0	0	-1586.6	19.4
17	H-TVP-VAR-SV (3)	0	0	0	1	1	-1586.9	26.5
18	H-TVP-VAR-SV (3)	0	0	1	1	0	-1588.1	86.5
19	H-TVP-VAR-SV (3)	0	0	1	0	1	-1586.3	14.6
20	H-TVP-VAR-SV (3)	0	1	0	0	1	-1585.8	8.4
21	H-TVP-VAR-SV (3)	0	1	0	1	0	-1589.1	238.4
22	H-TVP-VAR-SV (3)	0	1	1	0	0	-1588.8	170.9
23	H-TVP-VAR-SV (3)	1	0	0	0	1	-1586.1	12.0
24	H-TVP-VAR-SV (3)	1	0	0	1	0	-1588.1	91.4
25	H-TVP-VAR-SV (3)	1	0	1	0	0	-1587.5	49.7
26	H-TVP-VAR-SV (3)	1	1	0	0	0	-1588.6	146.8

Table 2. (continues)

Model		Equation					Criteria	
N°	Name	IPX	GC	GK	GDP	TR	ML	BF
27	H-TVP-VAR-SV (4)	0	0	0	0	1	-1587.4	44.8
28	H-TVP-VAR-SV (4)	0	0	0	1	0	-1590.0	561.4
29	H-TVP-VAR-SV (4)	0	0	1	0	0	-1589.3	298.0
30	H-TVP-VAR-SV (4)	0	1	0	0	0	-1589.5	364.6
31	H-TVP-VAR-SV (4)	1	0	0	0	0	-1589.8	472.5
32	VAR-SV (5)	0	0	0	0	0	-1590.8	1348.6

Table 2 reports marginal likelihood (ML) and Bayes Factor (BF) for 32 estimated models with one lag which range from TVP-VAR-SV, where no equations are constant, to VAR-SV, where every equation is constant. Columns IPX, GC, GK, GDP and TR take values of 0 or 1 to indicate if the equation that determines that variable is constant or time varying. For example, model 31 is a H-TVP-VAR-SV with 4 constant equations (GC,GK,GDP,TR) and 1 time varying equation (IPX).

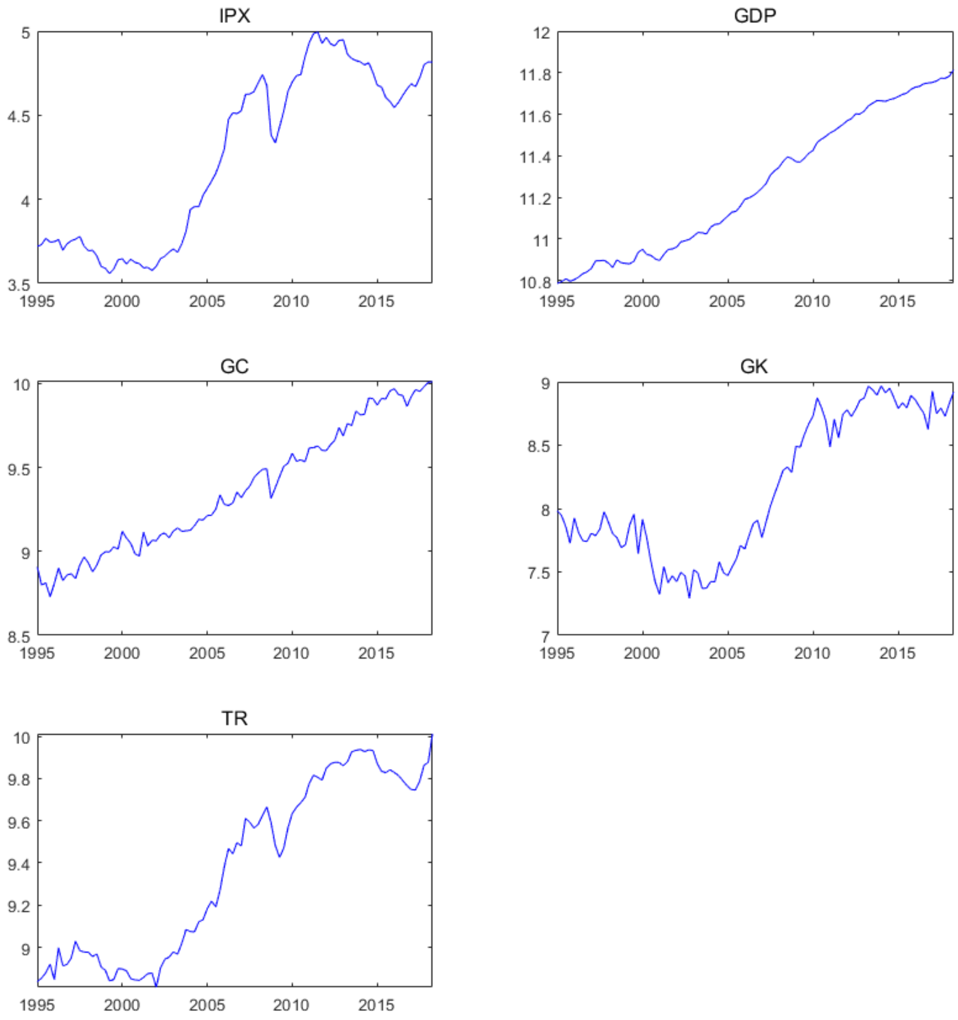


Figure 1. Variables in Log-Levels

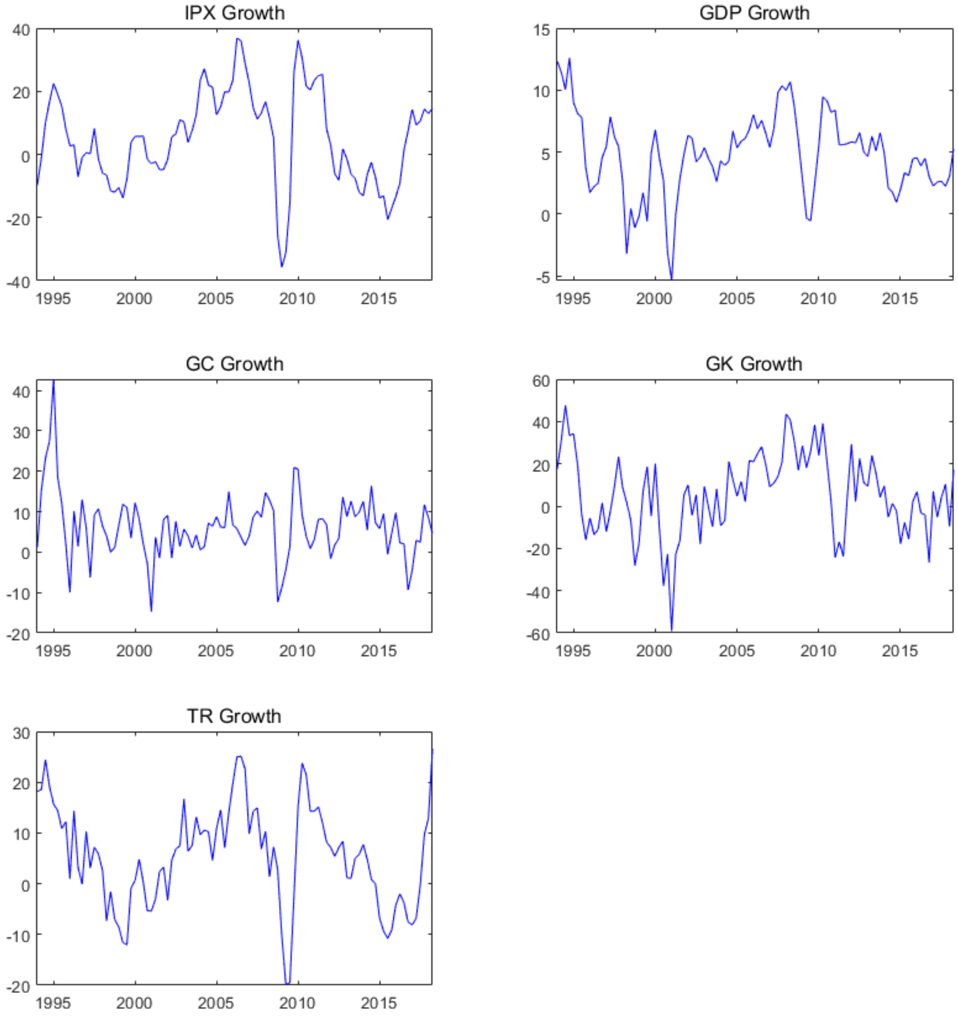
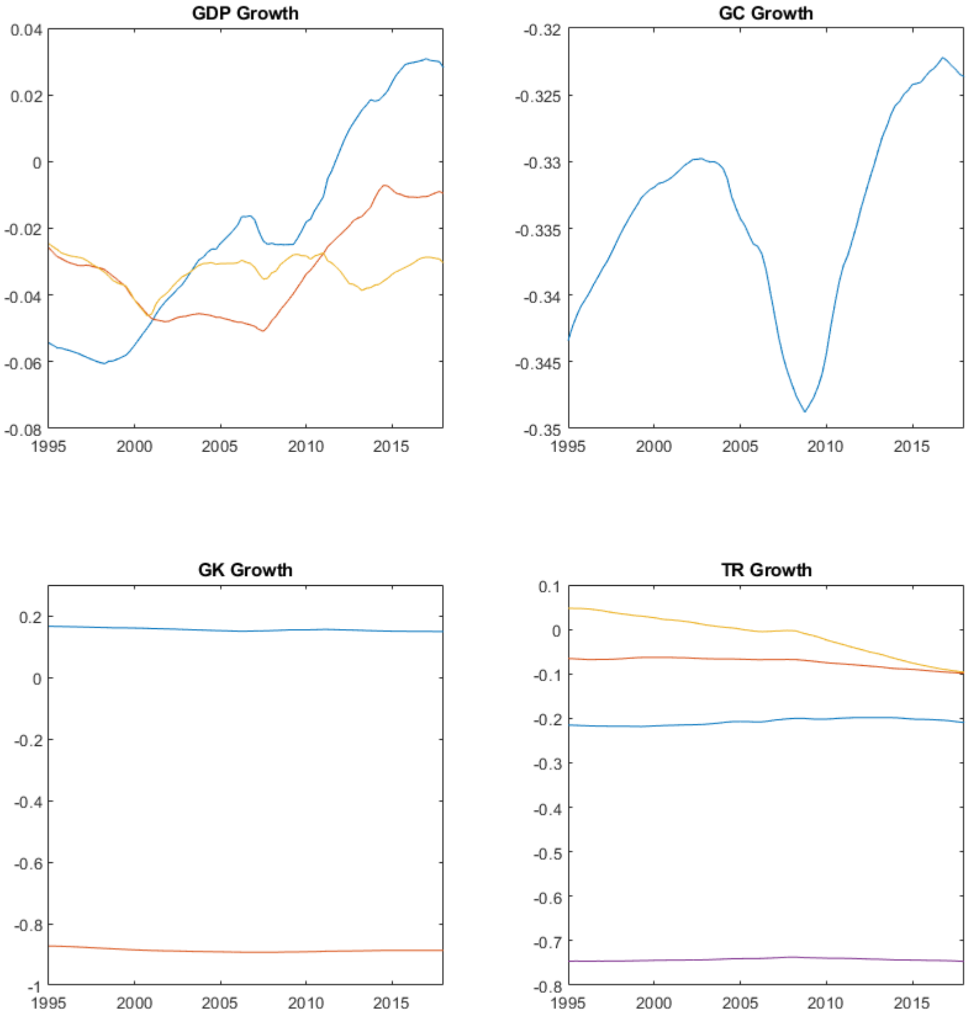


Figure 2. Variables in Annual Growth Rates


GDP Growth

GC Growth

GK Growth

TR Growth

Figure 3. Contemporary Parameters. Lines represent contemporary parameters from a TVP-VAR-SV model. Blue lines are associated to IPX growth, red lines are associated to current expenditure growth, yellow lines are associated to capital expenditure growth and purple lines are associated to GDP growth.

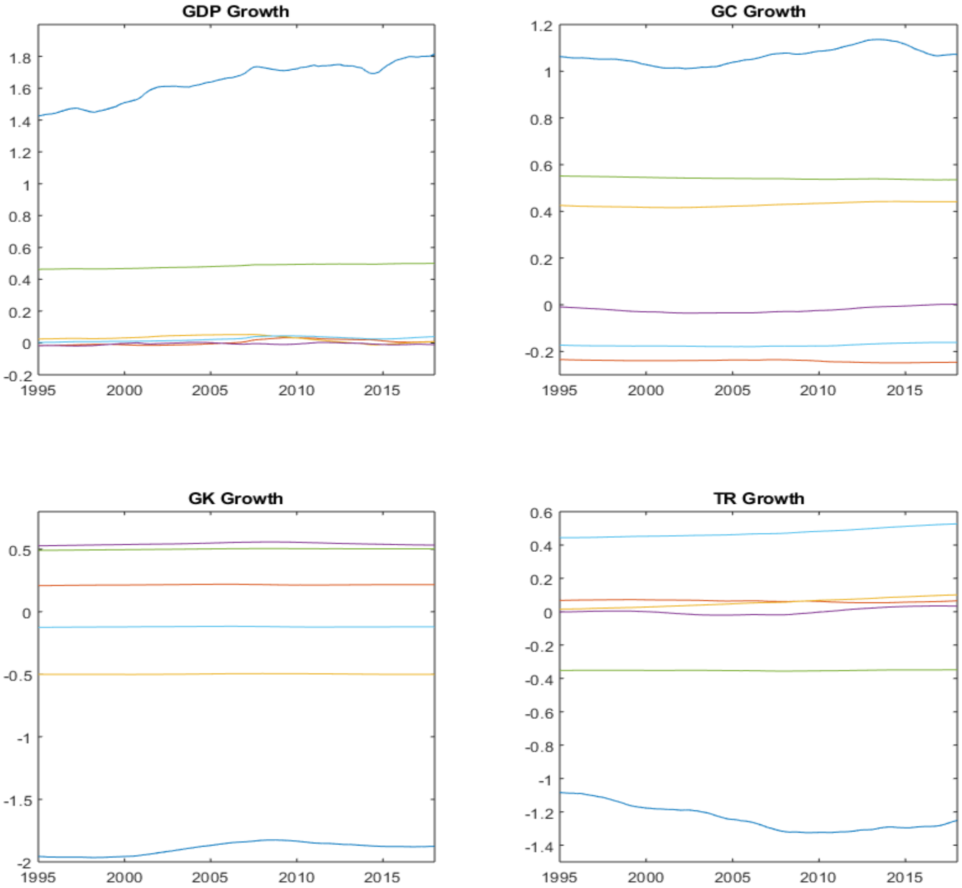


Figure 4. Intercepts and Lagged Variables Parameters. Lines represent intercept and lagged variables parameters from a TVP-VAR-SV model. Blue lines are associated to intercepts, red lines are associated to lagged IPX, yellow lines are associated to current expenditure, purple lines are associated to lagged capital expenditure, green lines are associated to lagged GDP and light blue lines are associated to lagged revenues.

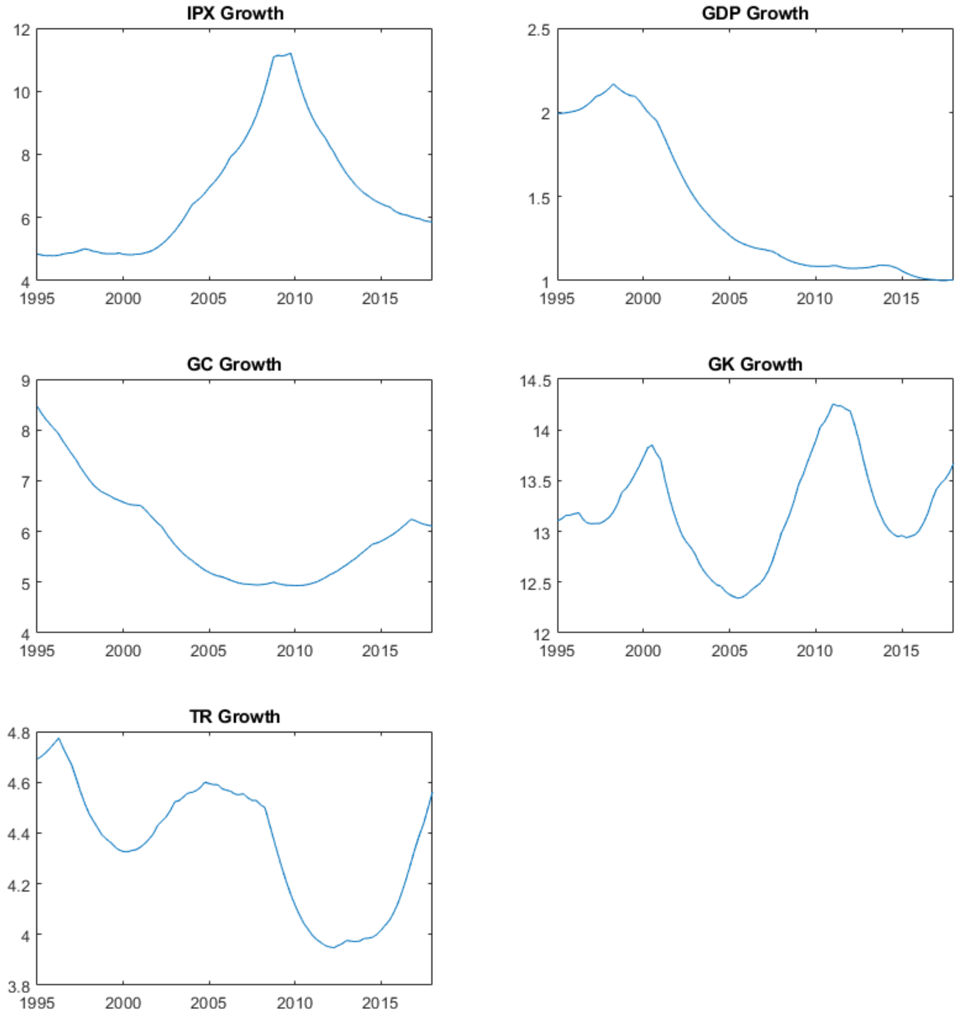


Figure 5. Stochastic Volatility

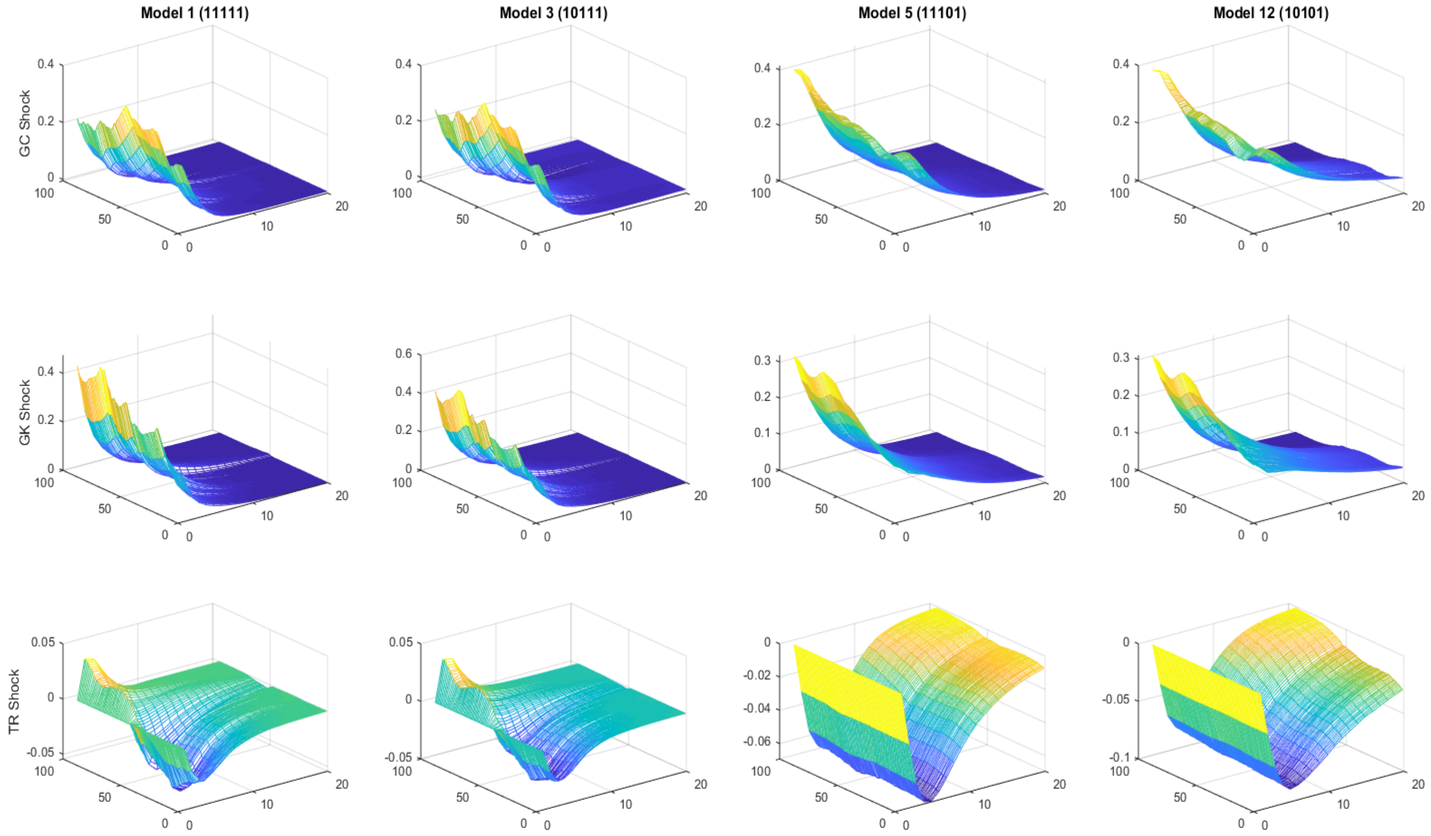


Figure 6. Response of GDP to Fiscal Shocks in every quarter from 1995Q1 to 2018Q2

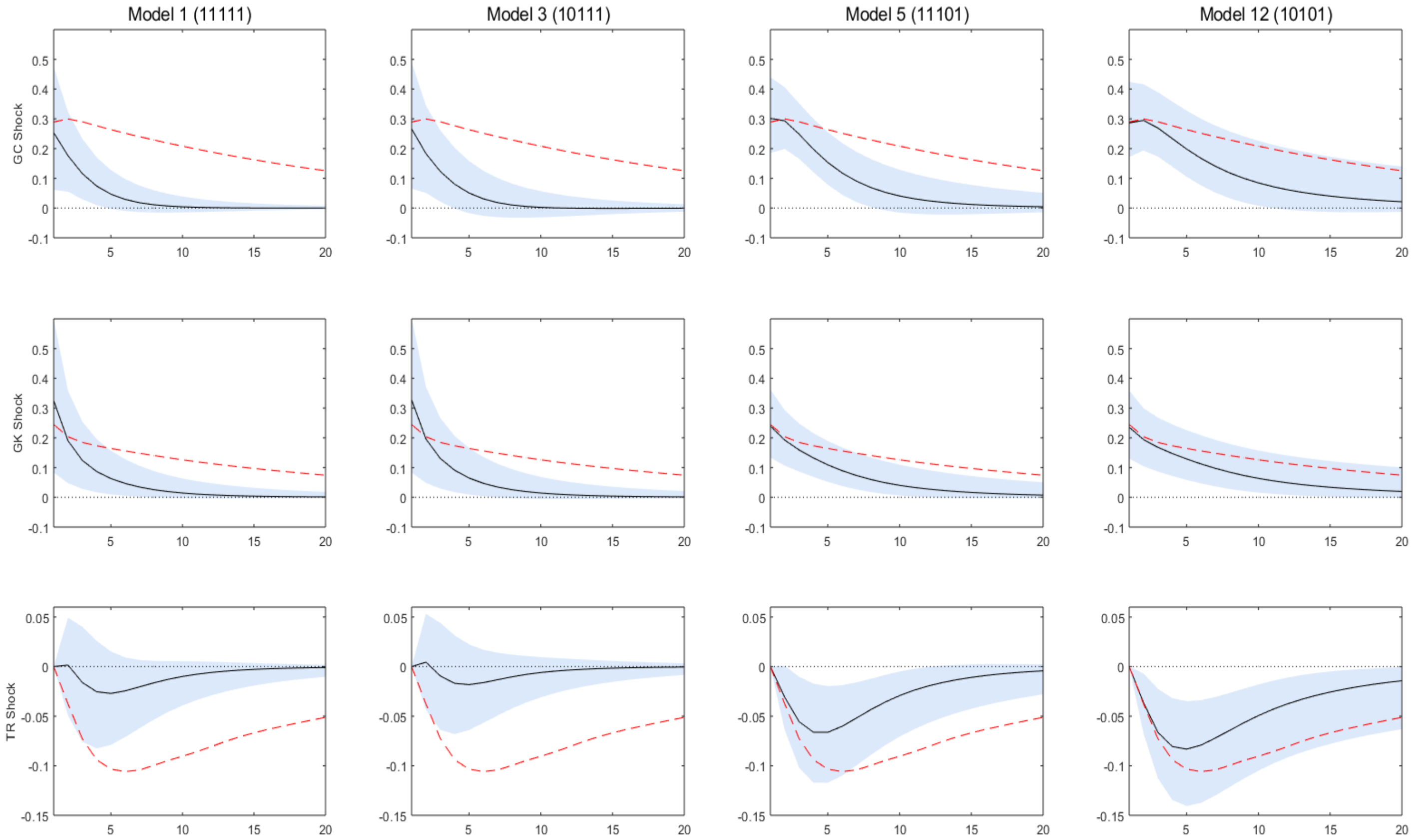


Figure 7. Median Response of GDP to Fiscal Shocks 1995Q1-2018Q2. Dashed lines correspond.to the Mean Response of a CVAR-SV model.

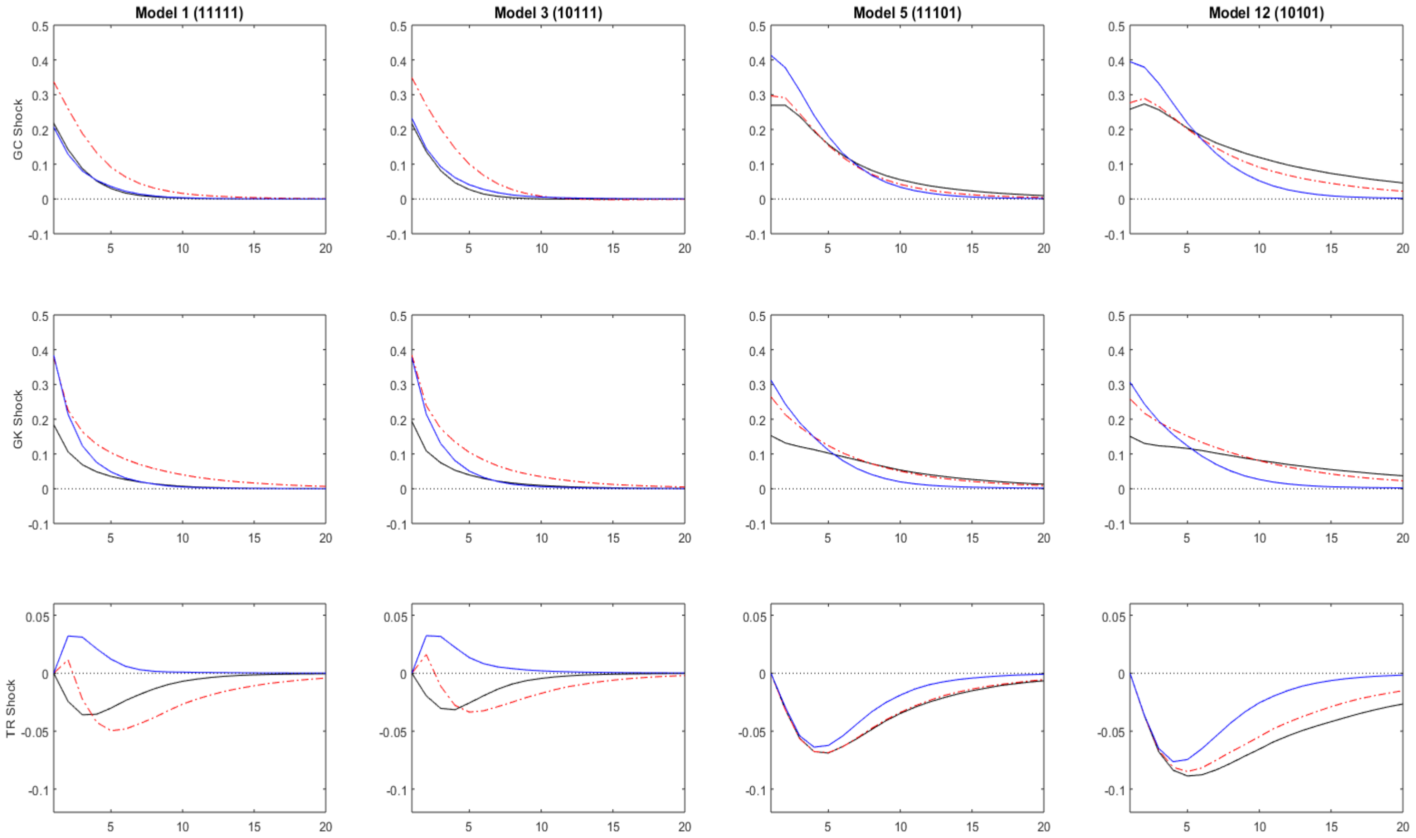


Figure 8. Median Response of GDP to Fiscal Shocks in three points of time. Black lines correspond to 1996Q1, red dashed lines correspond to 2007Q4, and blue lines correspond to 2017Q2.

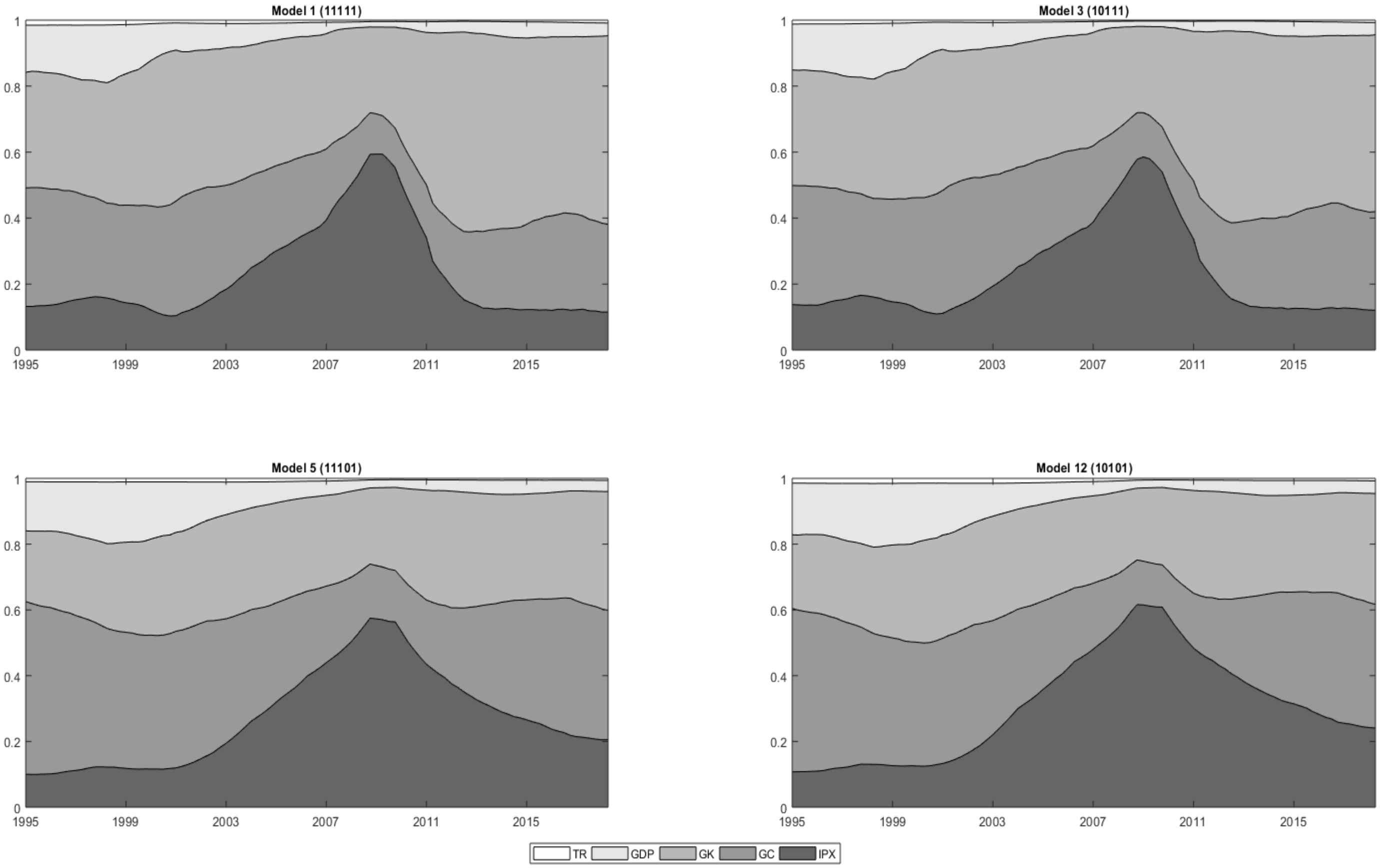


Figure 9. Five Year Forecast Error Variance Decomposition of GDP Growth

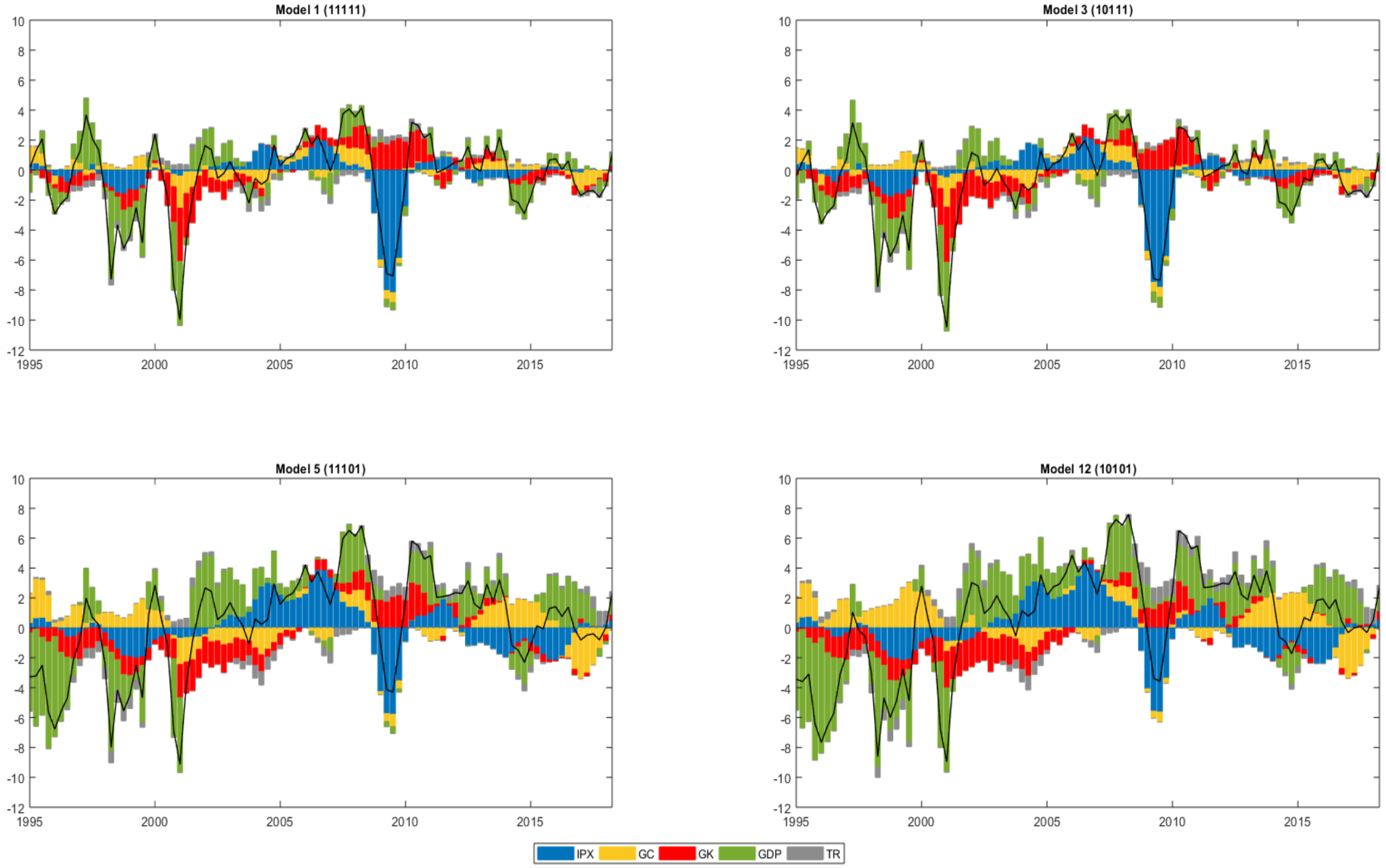


Figure 10. Historical Decomposition of GDP Growth

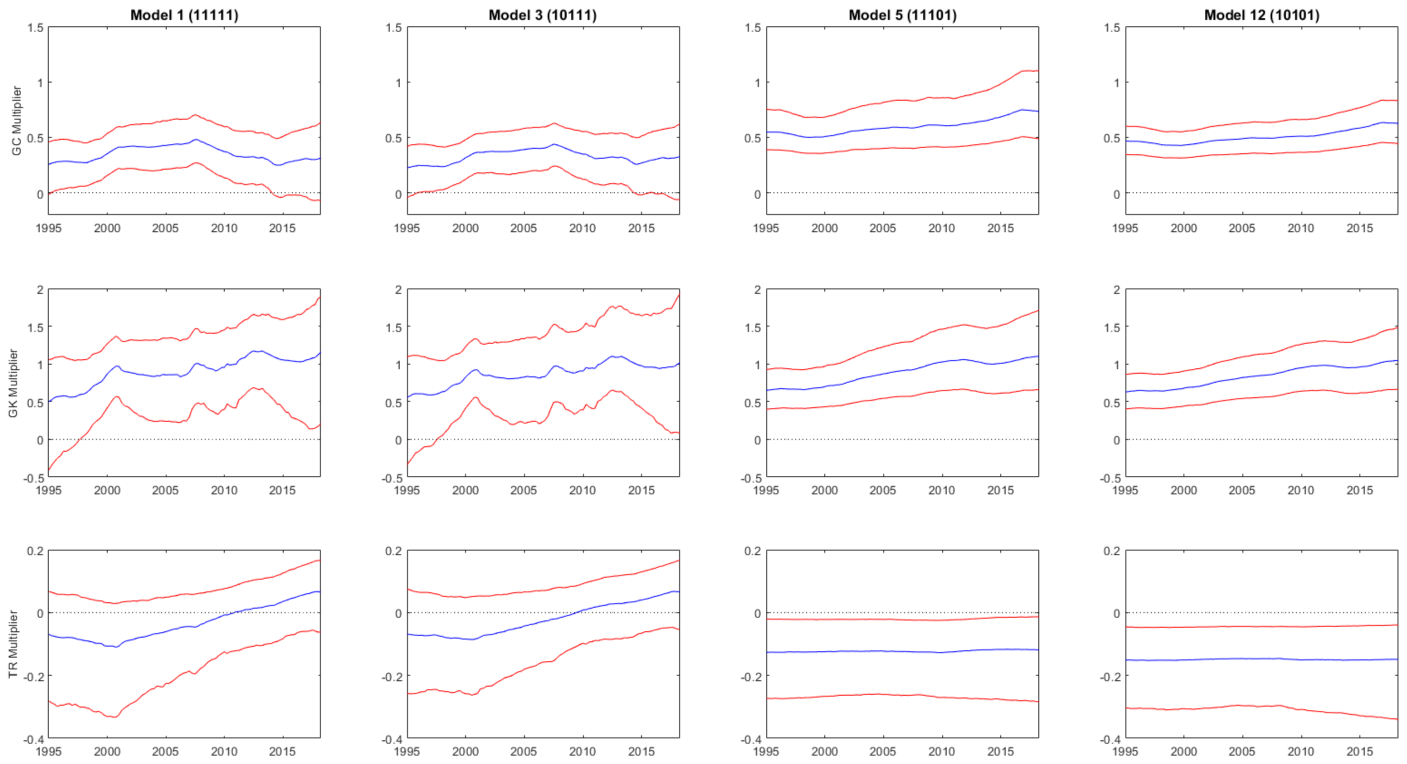


Figure 11. One-Year Fiscal Multipliers

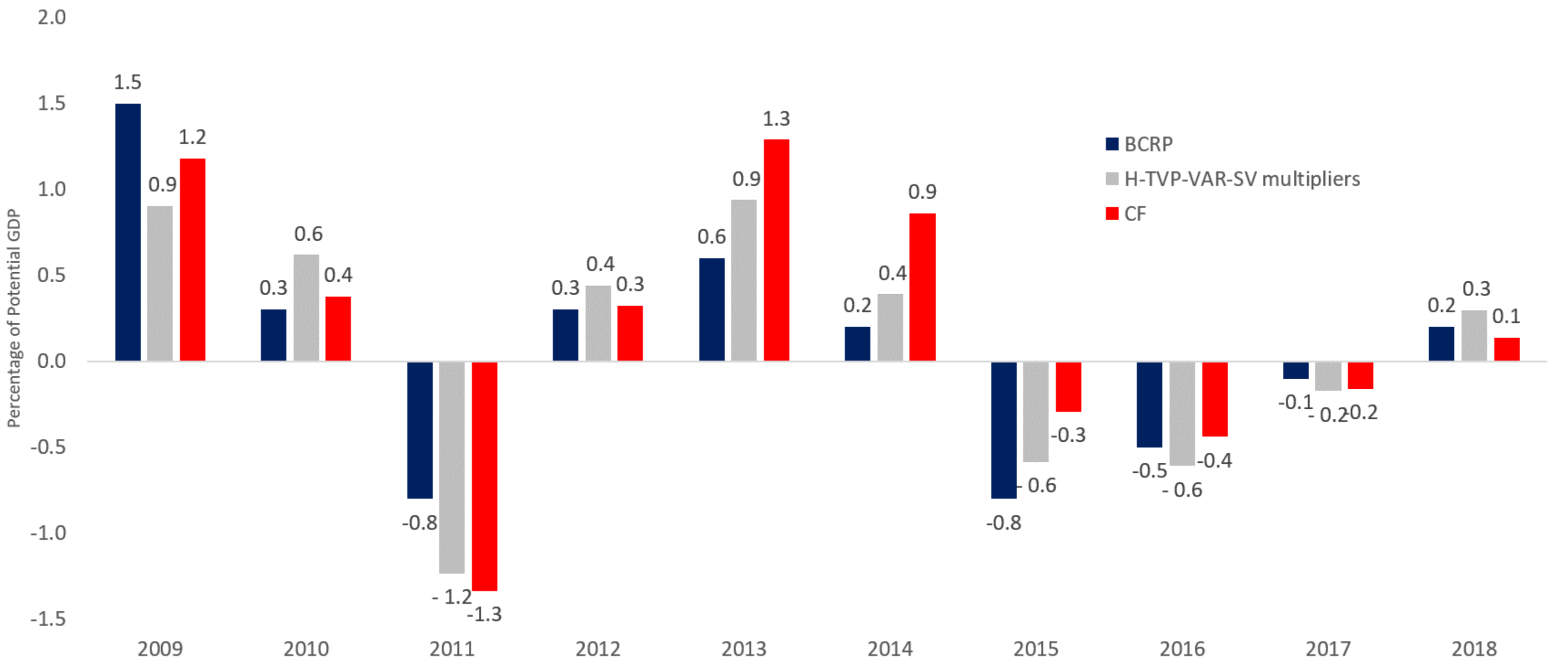


Figure 12. Aproximations to fiscal policy impact on economic growth. Blue bars correspond to Peru´s Central Bank (BCRP) estimates, red bars to Fiscal Council´s estimate and gray bars to this documents application.

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