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GILBERTO DA SILVEIRA BARROS NETO

FISCAL EFFECTS IN BRAZIL: MULTIPLE TIME SERIES APPLICATIONS

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Thesis submitted as a partial requirement for the degree of doctorate in Development Economics at the Program of Development Economics, Sector of Applied Social Sciences, at the Federal University of Paraná.

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ABSTRACT

The present study estimates the dynamic effects of Brazilian fiscal policy – i.e., the impacts of government spending and tax receipts on economic activity. The analysis is based on interpretations of impulse-response functions (IRFs) derived from vector autoregressive (VAR) models. In Part I, by assuming several structures on the contemporaneous correlations between endogenous variables, structural models were defined. Then, two models were estimated: the first, the basic model, with three endogenous variables (spending, tax receipts and output); and the second, the extended model, with five endogenous variables (the overall spending was replaced by three spending categories: benefits, wage and defrayals). The evidence suggests that spending shocks has positive effects on economic activity; however, these effects are significant only in the case of defrayal spending shock. Tax receipts shocks, on contrary, has negative and highly significant effects on output – but only when the structural model is identified with a high output-elasticity of taxes (the elasticity is one of the parameters of the matrix of contemporaneous impacts of the VAR model), as seems to be the case, by external calculations. Brazilian fiscal policy turned out to be very counter-cyclical – the consequence of a significant tax receipt response to business cycle together and an insignificant spending response. Part II departs from Part I's methodology and takes another approach to identify fiscal shocks. Instead of specifying the magnitude of the contemporaneous correlations between the variables, the alternative method localized four *fiscal episodes,* i.e., four periods in which the variation of spending or tax receipts was too high to be deemed as normal realizations of the stochastic processes. These fiscal episodes were then supposed to be exogenous shocks; and as such, could be isolated by dummies in a standard intervention analysis framework. The four episodes comprised *i)* one spending increase [1998:1]; *ii)* one tax increase [2001:2] and two spending decreases [2003:1; 2008:1]. Only the first spending contraction generated an effective response – statistically significant – in accordance with the impulse-responses from the structural identification (the decrease in spending caused a reduction of output); the other three episodes generated output dynamics contrary to the *a priori* expectations formed by the results in Part I. In sum, even though the average output response to spending and tax receipts (positive for the first shock, negative for the second) seems to be given by the results of the structural identification, specific shocks might cause very distinctive reactions on the economy, as Part II makes clear. Finally, it's important to highlight that all the models in the present study were estimated for two separate data generating processes (DGP) assumptions – first under the unit-root hypothesis (stochastic-trend assumption), and then under deterministic-trend hypothesis (trend-stationarity). This double-estimation strategy was performed in view of the fact that formal unit-root tests could not give unambiguous indications about the true DGP of the dataset.

JEL classification: C32, E32, E62.

RESUMO

O presente estudo mensura os efeitos dinâmicos da política fiscal no Brasil – ou seja, uma mensuração dos impactos do gasto do governo e receita tributária na atividade econômica. A análise se baseia em interpretações de funções impulso-resposta (FIRs) derivadas de modelos vetores auto-regressivos (VAR). Na Parte I, pela imposição de estruturas especificas para o impacto contemporâneo das variáveis endógenas, tipos de modelos VAR estruturais puderam ser definidos. Dois modelos foram estimados: o primeiro, com três variáveis (gasto do governo, receita tributária e produto); e o segundo, com cinco variáveis endógenas (substituição do gasto geral por três categorias: benefícios, salários e outras despesas de custeio e capital). Os resultados sugerem que os choques no gasto do governo causam efeitos positivos sobre o produto, mas os efeitos são significativos somente no caso da última categoria (outras despesas de custeio). As receitas tributárias afetam o produto de forma significativa e negativa somente se a elasticidade-produto dos impostos for elevada (um dos parâmetros da matriz de impactos contemporâneos dos modelos estruturais), conforme verificado na literatura. Finalmente, a política fiscal no Brasil foi estimada como contra-cíclica. Este resultado se deve ao comportamento dos gastos do governo e receita tributária diante de um choque no produto (ciclo de negócios): as receitas tributárias responderam de forma positiva e significativa; enquanto que a resposta dos gastos foi estatisticamente insignificante. Na Parte II, uma outra abordagem de mensuração dos choques fiscais é adotada. Ao invés de identificar a magnitude das correlações contemporâneas das variáveis endógenas, a nova abordagem identificou quatro *episódios fiscais*, ou seja, quatro períodos nos quais a variação do gasto do governo e da receita tributária seria grande demais para serem interpretados como realizações usuais do processo gerador de dados. Esses episódios fiscais foram assumidos como sendo eventos exógenos e, consequentemente, puderam ser isolados através de variáveis *dummy*, cujos impactos sobre o sistema pode ser derivado pela abordagem de análise de intervenção padrão. Dos quatro episódios, um é de aumento de gastos; um de aumento de impostos e dois de redução de gastos. Somente um dos dois episódios de redução de gastos – o ajuste fiscal ocorrido em no primeiro trimestre de 2003 – gerou impactos sobre o produto conforme as funções impulso-resposta dos modelos estruturais da Parte I; os outros três episódios geraram uma dinâmica do produto contrárias às expectativas *a priori*, especialmente depois das evidências apresentadas pelos modelos estruturais da primeira parte. Em suma, apesar da resposta média do produto aos choques de gasto e de impostos parecerem dadas pelos modelos estruturais, choques específicos podem causar dinâmicas distintas, como a Parte II deixa claro. Por fim, nas duas abordagens (Partes I e II), todos os modelos foram estimados duas vezes, uma para cada suposição acerca do processo gerador de dados (PGD): uma vez assumindo que todas as variáveis são processos de raiz unitária e outra assumindo que as variáveis são estacionárias ao redor da tendência. Essa estratégia de dupla estimação é uma solução ao resultado dos testes formais de raiz unitária, que não conseguiram retirar a ambiguidade da real natureza do PGD de todas as variáveis utilizadas.

Classificação JEL: C32, E32, E62.

SUMMARY

CHAPTER 1: INTRODUCTION

The debate about the effects of fiscal policy has being intensified since the global financial crisis (initiated in 2008) and its consequences, like the European debt crisis (roughly initiated in the end of 2009). Research efforts to measure the economic impacts of government spending, and also of taxation, gained impetus especially after stimulus legislations were passed by United States congress and European legislative bodies – at the same time that interest rates of government bonds of many developed countries reached historic lows: the outcome of aggressive monetary policy of several Central Banks. Even though one could expect fiscal policy to attain maximum power during such cases as great recessions, the fact of the matter is that the debate about the strength of fiscal policy is open: whether about the effects during normal times or during a great crisis [see Blanchard and Leigh (2013), Auerbach and Gorodnichenko (2012, 2013), Owyang, Ramey and Rubairy (2013) and Ramey and Rubairy (2014)].

Maybe the majority of the current research on the topic uses the methodology of vector autoregressive (VAR) models to measure the impacts of fiscal impulses (see Chapter 2). The same is true in the Brazilian literature, even though the research is much more scarce in comparison with United States and Europe. In Brazil, as in other countries, the debate did not form strong and definitive consensus. The empirical applications disagree on the significance, strength and even the sign of the output responses to fiscal innovations. In the VAR literature, the most important issue refers to the correct identification of the structural shocks of the system, i.e., the identification of truly exogenous shocks. Naturally, in fiscal literature, the focus is in the correct identification of the fiscal shock – usually the spending and tax shocks – allowing a correct measure of their impact on the economic activity. More than elsewhere, the Brazilian research relies heavily on the structural models (SVARs)[1], whether by the structural identification *per se* or by the Choleski decomposition (see Chapter 3). The structural identification tries to identify the exogenous shocks by imposing a specific structure on the contemporaneous correlations of the endogenous variables of the autoregressive system.

[1] The method is also popular in the international literature.

This study tries to contribute with Brazilian VAR literature in several ways. The main objective is still to measure the effects of fiscal policy on economic activity – carried out by measuring the impacts of government spending and tax receipts on the national output. The objective is fulfilled through the analysis of impulse-response functions (IRFs), derived from the reduced-form autoregressive models, after the application of some identification procedure that allows the uncovering of structural shocks. Besides measuring the effects of the overall spending and tax receipts, this research also measures the impact of three spending categories (which the summation is equivalent to the overall spending): *i)* benefits spending, *ii)* wage spending and *iii)* defrayal spending. Defrayal spending, in particular, comprises the capital spending (investments) of the government sector. In addition, the VAR method opens the possibility of assessing the opposite impact, that is, the impacts of business cycle on fiscal variables. This last feature permits taking conclusions regarding the nature of the Brazilian fiscal policy (pro-cyclical or counter-cyclical) in general.

To achieve the objective, Part I applies structural VARs to reckon Brazilian fiscal effects, using a considerable larger sample, at least in comparison with previous empirical applications with Brazilian data. In Chapter 4, the data analysis revealed the impossibility of reckoning the true data generating process (DGP) of the dataset, in one direction (unit-root) or the other (stationarity). An accommodating solution, then, was adopted: estimate every model twice: first assuming that all the relevant variables are unit-root processes; and once again assuming trend-stationarity. The comparison between results from these distinct hypotheses suggests that the DGP assumption can make the difference in terms of the persistence of some impulse-responses. In Chapter 5 the basic reduced-form VAR model[2] is estimated and two identification strategies are tested: the Choleski decomposition and the structural identification *per se.*[3] In Section 5.1, the recursive model, when applied to the reduced-form model, brings forth the first set of impulse-response functions. The IRF investigation attests that spending shocks do not generate significant output responses (even though positive); and neither does the tax shocks. On the other hand, the structural identification, carried out in Section 5.2, by the imposition a high output-elasticity of taxes (output-tax elasticity), finds an output response to tax receipts shock that is highly negative and strongly significant (with the spending shock still positive and insignificant). Section 5.3, performs a sensitivity analysis on the output-tax elasticity parameter – finding a positive correlation between the assumed value of this parameter and the magnitude of the instantaneous tax-output elasticity which, then,

[2] With three endogenous variables: government spending, tax receipts and output.
[3] Chapter 3, on methodology, outlines in detail the differences between the two methods.

generates strong output response to tax shocks. Both the recursive and the structural identifications found that the tax responses to output shocks are significant; in the recursive method with maximum value one quarter after the initial shock and in the structural model with maximum value already at impact. The spending response to the same shock is statistically insignificant. Chapter 6 expands the basic model, replacing the overall spending by the three spending categories. The expansion reveals the reason behind the ineffective spending policy: the defrayal spending shocks provoke a statistically significant positive output response; however, the same is not true about benefits and wage spending shocks, which, by not generating significant output responses, drive the overall spending shock to statistical insignificance. The overall dynamic effects of tax shocks in the expanded model are more or less the same found before.

In Part II a different approach is used (Chapter 8) to identify exogenous fiscal shocks. To allow comparisons, however, the autoregressive reduced-form model in Part II is very similar to the one used before: the estimation uses the same sample; the same endogenous variables; is carried out twice, for two DGP assumptions and uses the same lag structure. Again, the difference is in the method of identification of the fiscal shocks: the new approach makes the inclusion of four dummy variables in the reduced-form model as exogenous variables. The four dummies locate the four *fiscal episodes* – four quarters that are deemed as representing exogenous tax or spending shocks, according to the criterion established in Chapter 9: the largest quarter-to-quarter variation of the spending-GDP ratio (tax) receipts-GDP ratios were considered as singular events; to be controlled separately. The dummies represent the following exogenous episodes: a spending increase [1998:1]; a tax increase [2001:2]; and two spending reductions [2003:1; 2008:1]. By representing the fiscal episodes by the four dummies one can derive, directly from the reduced-form models, impulse-response functions that are structural – in the sense that they measure the system's responses to exogenous shocks and not needing to identify any contemporaneous correlations as the standard structural models of Part I. Also unlike Part I the IRFs derived from the dummies are dynamic responses from specific cases – and not some kind of average response to a typical shock: they measure the consequences of specific episodes. Even taking into account this specific characteristic of the four fiscal episodes, the results are striking (Chapter 11). Only the spending contraction has generated an effective response (statistically significant) in accordance with the impulse-responses from the structural identification. The first episode of spending reduction provoked a strong negative response of the economic activity; the other three episodes, had insignificant responses. The spending increase [1998:1] and the second spending decrease [2008:1] also with signs opposite to the *a priori* expectation – hardly resembling the natural output responses from typical fiscal shocks from the structural identification.

Thus, the body of evidence found in the present study can be summarized in the following statements:

- In the structural identification government spending cannot significantly stimulate economic activity;
- Notwithstanding, the structural identification found that defrayal spending, one of the three spending categories, could stimulate the economy;
- Tax receipts innovation had a negative effect on output. This results is dependent on the value of the output-tax elasticity (the contemporaneous impact of output on tax receipts), which was assumed to be high;
- Formal test could not uncover the true data generating process of the variables of the model, i.e., it was not possible to specify if the dataset is composed by unit-root or trend-stationary processes. The structural model under trend-stationarity tends to generate more persistent impulse-response functions;
- Even though the structural identification measured the average effect of a typical spending shock to be positive, only one of the three spending episodes under the narrative approach of Part II – the spending contraction in 2003:1 – generated the dynamic response predicted by the structural identification. The other two episodes did not result in significant output responses;
- Likewise, the structural identification found that the average output response to a typical tax shock would be strongly negative. But even though the tax episode in 2001:2 did cause a negative output dynamics, the response was not significant.

PART ONE

APPLYING THE SVAR METHODOLOGY IN BRAZIL: VARIABLE CHOICE AND IDENTIFICATION STRATEGY

CHAPTER 2: SVAR APPLICATION

2.1 INTERNATIONAL LITERATURE

The long debate regarding fiscal effects has generated a prolific literature. Efforts to measure fiscal policy can be traced back to the first decades after the World War II, when large structural econometric models, with Keynesian inclination, were the norm. On the contrary, in the more recent decades, vector autoregressive models have become the main econometric approach to assess the effects of fiscal policy, and monetary policy, in view of the rejection of overidentified models (Sims, 1980) and because the capacity of VARs to deal with Lucas (1976) critique.

On another level, the autoregressive approach can also be directly compared with the theoretical DSGE models.[4] It is possible, for instance, to construct a DSGE model using a wide range of assumptions – regarding consumer behavior, price formation, market structure, government sector, etc. – and compare their impulse-response functions, say, due to a fiscal innovation, to IRFs derived from a empirical VAR model using actual data. Two examples of comparisons between theoretical and empirical impulse-responses are the works of Ramey and Shapiro (1998) and Fatás and Mihov (2001). The first estimated a model with two types of capital; comparing the DSGE impulse-responses with impulse-responses functions of univariate time-series models due to spending shocks in the form of dummy variables; the second compared a more standard neoclassical DSGE model with government sector to a semi-structural, medium-sized autoregressive model.[5]

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[4] Dynamic Stochastic General Equilibrium models.

[5] There is a wide range of literature using the so-called *dynamic stochastic general equilibrium* (DSGE) models – covering many topics. These models are also popular in fiscal policy research. For example, models with a neoclassical inclination, as for example, Edelberg, Eichenbaum and Fisher (1999), Baxter and King (2003), Burnside *et al.* (2004) and Eichenbaum and Fisher (2005), predict that a deficit-financed rise in government spending increases output through the increase in hours worked, decline in consumption and increases in private investment. Neo-keynesian DSGE models, as Linnemann and Schabert (2003), gives roughly the same results, since the outcome of the neoclassical models are related to inter-temporal substitution of work and leisure through wealth effects. One can accommodate empirical regularity of increase in consumption after a

The popularization of the multiple time series analysis (there is, VAR analysis) in measuring fiscal shocks was not followed by a convergence, or at least an overwhelming body of evidence, favoring one particularly assessment of the impact of fiscal policy in general. This is somewhat discouraging, in one sense, especially when comparing with the state of monetary policy research, which, with the same method of analysis reached a relatively strong consensus about the potential of monetary policy to generate inflation. Professor Roberto Perotti, of the Boccòni University, summarizes as follows:

> While most economists would agree that a 10 percent increase in money supply will lead to some increase in prices after a while, perfect reasonable economists can and do disagree even on the basic qualitative effects of fiscal policy. (Perotti, 2004, p. 1)

The above assessment remains to be true. The empirical research using multiple time series approach has reached conflicting results. There are several factors behind this conflicting evidence. For one hand, there is the problem of *a priori* choices: the number of endogenous variables, variable definition, identification strategy, country characteristics and even the period of study (large dataset are only available for a handful of countries). On the other hand, there is the problem of the particular methodology: the choice goes from the more conventional methods of structural identification – whether the Choleski decomposition or the Structural identification *per se* – to more advanced methods like the Bayesian sign-restriction approach. Probably, one of the few consensus of the fiscal policy research refers to the necessity of inclusion of two fiscal dimensions, that is, the necessity of including a spending and a tax variable on the autoregressive model as the proper way to measure the economic consequences of the public sector, acknowledging the fact that a spending policy is completely different experiment than a tax policy. Thus, the choice of just one dimension as, for example, the public deficit, will bring misleading results due to the assumption of non-asymmetric consequences of the fiscal policy.

On the problem of working with different set of countries and/or different time periods, a good example is the work of Perotti (2004). Perotti uses the structural identification set forth by Blanchard and Perotti (2002) to measure the fiscal effects on economic activity, interest rates and inflation of five OECD countries.[6] The period of analysis went roughly from 1961 to 2001 (quarterly data), varying somewhat from country to country. Perotti found that fiscal

government spending shock through the inclusion of non-maximizing agents with rule of the thumb decisions and imperfect competition (Galí *et al.*, 2007).

[6] United States, United Kingdom, Australia, Canada and Germany.

multipliers would differ between these five countries, not only in magnitude but also in sign. By dividing the sample into two periods, Perotti also found that the same fiscal multipliers would be very different across time, for the same country. In some cases, the evidence even contradicted the *a priori* expectation of a *positive* output response to spending shocks and a *negative* response to tax shocks.

The reason of why fiscal multipliers can differ so much between countries is object of ongoing research. Ilzetzki, Mendoza and Végh (2013), applying the VAR method to a broad sample of countries, highlighted many characteristics that may be behind the variance of fiscal multipliers. First, the spending stimulus seems to be effective (i.e., generates statistical significant output responses), as a rule, only in developed countries; second, economic activity is sensible to spending stimulus when the country is under the fixed exchange rate regime, while, at the same time, countries under flexible exchange rates do not present statistically significant responses; also, open economies had small output responses in comparison to closed ones and, finally, high-debt countries tend to face negative multipliers.[7]

As previously stated, methodology behind a particular model also play a central role in the results. Probably, the most important aspect in measuring the effects any policy – at least in a vector autoregressive framework – is the procedure used to get the so-called *structural errors* (in contraposition to the *reduced-form errors*). Several methodologies were proposed to uncover the structural errors; and each methodology will generate a different set of such errors, for the same set variables that compose the autoregressive model and in same period of analysis. The chapter on the methodology (in the following) will give a clear understanding of why uncovering the structural errors rather than the reduced-form errors is crucial for the good measurement of the effects in the form of impulse-response functions. It suffices to say here that the structural errors are interpreted as exogenous shocks, and thus, the system's responses to such shocks are rightfully interpreted as real responses (in the sense that is a *ceteris paribus* analysis). On contrary, the original [reduced-form] prediction error of each equation is correlated with the errors from the other equation, precluding an economic interpretation of such shocks since they are not exogenous. Thus, the credibility of the impulse-responses of any autoregressive model is related to the credibility on gives to the identification procedure used in a particular application.

[7] The evidence of high-debt countries having *negative* spending multipliers is a multiple time series confirmation of the existence of the so-called *expansionary fiscal consolidations* found in case studies like Giavazzi and Pagano (1990) and Alesina and Perotti (1997). Expansionary fiscal consolidations are cases when a fiscal adjustment (rise in taxes, reduction of spending) expands output.

The most natural set of data to test different methodologies might be the U.S. macroeconomic dataset – with official quarterly fiscal and GDP (and its components) time series available from the 1950s onwards. For example, it's possible to contrast the results found by Blanchard and Perotti (2002) – that popularized the structural identification procedure – with the results of Mountford and Uhlig (2009) – which introduced the sign-restriction approach into the study of fiscal policy –, since both studies used the U.S. macroeconomic data for the same time period. Key to find structural errors in the approach of Blanchard and Perotti (2002) [BP, on the following] was the external calculation of the output-elasticity of taxes (or, output-tax elasticity) and its imposition on their autoregressive model.[8] Mountford and Uhlig (2009), building on the work of Uhlig (2005), identified structural errors through the sing-restriction approach, which, assuming that each type of shock would generate a certain behavior on the system's variables, that is, each shock would induce a certain pre-established behavior on the system's variables at the first quarters. BP found higher spending multipliers (0,9 ~ 1,29) than Mountford and Uhlig (0,65); the opposite being true for tax shocks (-3,57 for the latter; between -0,78 and -1,33 for the first). Even though both studies agree on the signs of the fiscal multipliers, the conclusion in terms of policy recommendation are quite different: BP would favor the position that a spending policy is more effective in affecting economic activity; while Mountford and Uhlig would favor a tax policy, in terms of the speed and magnitude of its impact on output. Ramey (2011) does a survey on recent estimations of U.S. spending multipliers, finding a relatively wide interval.

Advancing on the methodology, there are those studies that try to differentiate structural errors also regarding their sign (i.e., some models permit the study of *asymmetric* effects of the fiscal policy) and others that try to identify structural errors by grouping them according to regimes (especially regimes about the state of the economy). Examples of the latter type of identification are the works of Auerbach and Gorodnichenko (2012) and Baum and Koester (2011) – the first applied to the United States and the second to Germany –: both estimate *threshold VARs* models with the objective of showing that fiscal shocks are strongest at the lower part of the business cycle, i.e., when actual output is below the potential. The results of Auerbach and Gorodnichenko were contested by Owyang, Ramey and Rubairy (2013) and Ramey and Zubairy (2014), both using yet another methodology – the model of spatial

[8] Roughly, the reduced-form VAR model estimates the vector of endogenous variables as a function of it's own lagged vector of variables. The structural identification turns the contemporaneous correlations between the endogenous variables explicit (not given by the reduced-form model). In the BP model, one of these contemporaneous correlations is the output-tax elasticity. It's possible to restrict some values of these contemporaneous parameters in order to identify the structural model. See Chapter 4 on methodology.

dependency of Jordà (2005) – founding no substantial differences between fiscal effects between period of slack and periods of expansion, or even between period of lower-bound interest rates and periods of normal rates. In common with each other, though, these studies found Keynesian effects due to the fiscal shocks. On the other hand, Gogas and Pragidis (2014) work tries to implement the first type of identification, differentiating positive and negative fiscal shocks. The general result tend to support the presence of asymmetries, indicating that *negative* spending shocks, for example, tends to depress economic activity more than a *positive* shock would expand it.

2.2 APPLYING SVARS INTO BRAZILIAN DATA

The last section reviewed some studies that used other methodologies different from the traditional structural identification procedure. The objective there was to give clear idea about the fact that the impulse-responses functions dependent fundamentally on the method used to derive structural errors. Here, though, the focus in structural identification will be even clearer – since the application in the following will be based on this framework. As was the case in the international literature, at this point there isn't a broad consensus on the real effects of Brazilian fiscal policy. The next paragraphs will review in detail the relevant works that tried to measure the effect of government spending and tax on Brazilian economic activity. There is just a handful of relevant papers on the subject, and only one of them is not based on the structural identification approach: it is mentioned here because its results are in major contradiction with the rest of the Brazilian literature using structural identification or Choleski decomposition.

The evidence from the Brazilian VAR literature applied to fiscal policy ranges from the traditional Keynesian-like responses – the output responding positively to a positive spending shock together with negative responses of economic activity due to a positive tax shock – to cases with the exactly opposite dynamics. In the following, a brief survey is made on those national studies that tried to measure impulse-response functions from structural errors – exogenous errors – in order to estimate the effects of fiscal policy. These are the works of Peres (2006; 2012) and Peres and Ellery Jr. (2009); Cavalcanti and Silva (2010) – these using structural identification into three-variable autoregressive models, following Blanchard and Perotti (2002) –; Correia and Oliveira (2013) – which estimate structural models with five and six endogenous variables in a monthly dataset –; and lastly, the Bayesian (sign-restriction) application of Mendonça *et al.* (2009) – that applies the methodology into a six-variable model. The Bayesian model of Mendonça *et al.* is included here because their results are most distinct: the previous group of studies using structural identification could be sided as showing Keynesian results from fiscal policy or, at the limit, some showing evidence of ineffective fiscal policy; on the other hand, the sign-restriction approach found multipliers with the opposite signs, i.e., *negative* spending multiplier and *positive* tax multiplier. The aforementioned literature will, then, be reviewed in detail next, in the remaining of this section. In the process, the review will highlight some issues that still remain open and should be addressed in the following estimations. It seems that the structural methodology applied to Brazilian data is not yet exhausted and a thorough analysis could still improve the understanding of fiscal policy and its effects on the economy.

Peres (2006) and Peres and Ellery Jr. (2009) estimated a SVAR model with three endogenous variables – output, government spending and tax receipts. The period of analysis extended from 1994:1 to 2005:2 (quarterly data). Given the lack of a comprehensive dataset of consolidated government statistics – a pervasive problem affecting much of the work that uses Brazilian macroeconomic data –, the two fiscal variables (spending and taxes) covered only the central government sphere. Peres (2006; 2012) also computed the fiscal variables netting out the *transfers* (benefits, unemployment security, etc.) – getting close to the definition of fiscal variables used by BP. The assessment about the nature of the data generating process of the three endogenous variables, only the output was identified as being a unit-root process (by the traditional tests) and, thus, was inserted in the model in first-difference (rate of growth); fiscal variables, on contrary, were inserted in levels, considered to be mean-stationary. Finally, the results showed that the estimated output impulse-responses had the Keynesian-like behavior, i.e., showing a positive response to spending shock and negative response to tax shock. The first type of response was also the strongest. As a general characteristic, one could point to the fact that impulse-responses were not persistent, with significant responses at impact and at most after one quarter after the initial shock. Almost all de conclusions mentioned could be extended to the output's behavior in Peres (2012), which measure the impact of fiscal policy on the GDP and its components (consumption, investment, export and imports) for the period from 1994:1 to 2012:1. It's important to stress that the structural model of Peres (2006; 2012) follows BP also in the sense that they computed, outside the VAR model, the output-elasticity of tax (output-tax elasticity), which permitted a more flexible estimation of the structural matrix by opening another free parameter.[9] The value found by Peres will be used as a benchmark value in the present study. Later, then, testing with alternative values on the neighborhood of the benchmark will be useful in testing how the model fares with these different values.

Cavalcanti and Silva (2010) also measure the fiscal effect on output using the SVAR methodology in a model with three endogenous variables (spending, output and tax receipts). However, their main objective is to compare the impulse-responses of two models – the only difference between them being the presence in one of them of the public debt as an exogenous variable. The period of analysis goes from 1995:1 to 2008:1 (quarterly data). They use as proxy for tax receipts the estimated series of the consolidated government computed by Dos Santos and Costa (2008); an analogous series for consolidated government expenditures was recovered using the tax receipts series and Brazilian Central Bank's (Bacen) data on primary deficit. The characteristics and nature of the DGP of the dataset was not object of study: all the endogenous variables were inserted into the model in levels, without prior treatment. As sensitivity analysis, the authors tested several structural identifications, but the benchmark impulse-responses were derived from a recursive ordering (Choleski decomposition) with government spending ordered first, output second and taxes as the third and last variable. The analysis of Cavalcanti and Silva are compromised by inaccurate estimates – large confidence intervals – but still, some results are worth mentioning. Spending effects are weaker and less persistent in the model with debt; the model without debt shows a negative output response to a tax shock, while the model, while de model with debt has a positive output response (to the same kind of shock) after more or less eight quarters. The presence of debt also causes the spending response to tax shock to be more persistent, a possible outcome of relaxing the budget constraint. One could interpret the dynamics of tax increase as follows: a positive tax shock relaxes the inter-temporal budget constraint (probably improving expectations) but inducing more spending which, in turn, has a direct effect on output. However, one should bear in mind that spending shocks have virtually zero effect on output; the positive effect of tax must come almost exclusively from the indirect effect due to the improvement of expectations.

Correia and Oliveira (2013) relaxed the assumption of debt as an exogenous variable of the autoregressive model. The authors also compared the results between the model with debt

[9] See the methodology.

and the model without debt as one extra endogenous variable. Even without debt, the model of Correia and Oliveira is relatively large: it contains spending, output, inflation and interest rates – beyond, obviously, public debt itself. Contrary to the standard procedure of using quarterly data, Correia and Oliveira used a monthly dataset that spans from 1995:1 to 2012:12. The major objective of the work was to evaluate the impact of the shift in Brazilian fiscal rules with the sanction and enforcement of the *Brazilian fiscal responsibility act* (Lei de Responsabilidade Fiscal, LRF) in the second quarter of the year 2000. The new law was captured by a dummy variable in May.[10] The evidence suggests that the inclusion of debt causes the fiscal impulse (spending) to create a more persistent responses of economic activity: the spending shocks generates a positive output response that last for about five months, when including debt, or for just one month, when the model does not include debt.[11] These results favor the interpretation that modeling fiscal impulses without debt may introduce bias on the structural impulse-response by overestimating the responses of economic activity to fiscal shocks, spending shocks in particular. This particular result of Correia and Oliveira, however, has to be taken into account with care, and not at face value, since the autoregressive model has another bias (which can be even more serious), that is, the lack of a tax series to complete the dimensions of a fiscal policy. On the other hand, the evidence here can be accumulated to previous evidence, such as Cavalcanti and Silva (2010) that points to the same direction.

This completes the review of the relevant Brazilian literature on structural VAR models. Despite this, it is worthwhile to comment on the VAR model of Mendonça *et al.* (2009), which uses the approach of impulse-response sign-restrictions to the topic of fiscal policy. The sign-restriction methodology recovers the structural impulse-responses by imposing sign-restriction on the responses to shocks, i.e., for a shock to be considered, for example, as an actual spending shock, it has to generate certain kind of response on output and other variables. The set of sign conditions that will specify a particular shock is established *a priori*. The estimation of the sign-restriction model is made for the period between 1997:1 and 2007:4 (quarterly data); the model contains six endogenous variables – government spending, tax receipts, interest rates, output, inflation, and private consumption. All the endogenous variables are included in levels, without testing for the presence of unit-root processes. The

[10] The LRF imposed limits on personnel spending, on public debt and public borrowing for all sphere of government (federal, state and local); it also paved the way towards a more transparent public finances. See Nascimento and Debus (2003) and Giambiagi and Além (2011, Ch. 7).

[11] Sometimes the responses were not significant at all. Correia and Oliveira (2013) tested several structural identification strategies: each one related to an assumed self-imposed *fiscal rule* that the government could be obeying. It's impossible to bring details of every structural identification here.

authors use the aforementioned tax receipts series of Dos Santos and Costa (2008) [as share of GDP]. There is not much detail about the spending series; but it appears to be an unofficial estimate of consolidated government spending (as share of GDP) from the National Treasury. As mentioned earlier, the results from the sign-restriction approach are opposite to the structural identification models: the sign-restriction model did not find any Keynesian effects whatsoever. Economic activity responds negatively to spending shocks; an outcome derived from a strong crowding-out effect in investments, given the fact that the same shocks causes private consumption and interest rates to rise. Tax receipts shocks have, initially, negative effects on output. But the impulse-response quickly becomes positive and remains so. Finally, the output shocks generated a pro-cyclical fiscal policy with taxes and spending rising during the business cycle, latter at a higher rate than the former. This result conforms to the international literature that assigns pro-cyclical fiscal policy for developing countries. The evidence of Mendonça *et al.* should also be taken into account with care, since they have the same problems of Cavalcanti and Silva (2010) work, that is, a lack of statistical significance (large confidence intervals). These large confidence intervals could be, first, evidence of *Ricardian equivalence* (expectations) or, worst, inaccurate estimations *per se*. The results from the sign-restriction model, nonetheless, continue to be quite unorthodox.

The review above surveyed the relevant Brazilian literature that adopted the multiple time-series analysis and estimation of impulse-response functions to evaluate the fiscal effects on economic activity. The evidence is far from unambiguous: even thought the structural identification method provides some evidence that the Brazilian economy faces positive spending multipliers, the possibility that they are statistically insignificant exists. The evidence about the statistical significance of tax shocks depends on the value of the output-tax elasticity. The recursive method will usually estimate weaker tax multipliers probably because the contemporaneous output-tax elasticity endogenously estimated by the Choleski decomposition is relatively low. When considering high elasticity values, such as in Peres (2006), there is good ground to expect significant negative multipliers. One has to keep in mind the results from non-structural models, like the Bayesian sign-restriction approach, that found some evidence of non-keynesian responses to fiscal shocks.

At the same time, the Brazilian empirical research has left some gaps open that should be addressed in a new contribution to the topic. First, an analysis of the previous works would reveal that they are conducted assuming (sometimes implicitly) a data generating process to the variables of the empirical model. The DGP is ignored in Mendonça *et al.* (2009), Cavalcanti and Silva (2010) and Correia and Oliveira (2013). This is problematic, especially in the last two studies, since they rely on classical time-series econometrics. In fact, textbook exposition of the VAR method assumes that the vector of endogenous variables is *stationary*, thus guaranteeing the stability of the model. Peres (2006; 2012) and Peres and Ellery Jr. (2009) did perform unit-root tests, but those were circumscribed to the traditional unit-root tests, without paying attention to the problem of structural change (which can bias the results). After the description of the dataset, the second section of Chapter 4 will present more sophisticated unit-root tests that take into account potential structural breaks on each time series. Those tests make clear that the problem of exogenous shifts can (and do) alter many previous conclusions of the traditional tests. The conclusion there is that is not possible to drawn unambiguous conclusions about the nature of the time trend of the relevant variables. The problem of uncertainty regarding the nature of the trends should be specifically addressed.

Second, there is the issue of how to identify the structural model. A good practice is to exactly-identify the model – i.e., not imposing more restrictions than the absolute necessary – which is followed in the following estimations. Assuming that Peres (2006; 2012) calibration of the output-tax elasticity is reliable, it's possible to set another parameter of the contemporaneous correlation free (structural matrix) and still maintain the exactly identified model. Peres estimated the elasticity as 2 – that is, a one percent rise in output would increase tax receipts by 2 percent –, indicative of a high average marginal tax rate for the overall economy. This would explain why tax receipts grew above the overall economy. It should be noted, however, that Ilzetzki (2011) found a much lower value for the same elasticity parameter. This raises the question of which of the two estimated values are closer to the true value. A possible procedure that could give some understanding of this issue is to perform a sensitivity analysis on the elasticity.

The restriction of the output-tax elasticity parameter relates to the debate of the proper way to identify a structural model. Peres (2006; 2012) follow the procedure set forth by Blanchard and Perotti (2002) in specifying the automatic response of tax receipts to the business cycles, assuming also that the government does not have the ability to a discretionary response within the same quarter. Cavalcanti and Silva (2010) and Correia and Oliveira (2013), on contrary, identified their model testing several *fiscal rules* that the government might have been following. Even though a fiscal rule could be interpreted as not being a discretionary policy in the strict sense of the term, it seems that it presupposes a great ability, by the government, of foreseeing economic shocks and respond to them properly and timely. This is a problematic assumption to be made regarding quarterly events, as Blanchard and

Perotti (2002) compellingly argue; and even more so on a month-to-month basis. Many structural identification models in the international literature follow BP strategy and dismiss the strategy of fiscal rules. The same is done is this study.[12]

Finally, there is another issue that was ignored by the Brazilian literature. With the exception of Peres (2006) – that beyond a basic model with three endogenous variables, estimated also an extended version dividing government spending variable into consumption and investment – all the aforementioned Brazilian studies focused on the overall effect of spending. Even though the overall spending effect should not be overlooked, more effort should be focused on uncovering the effects on economic activity of particular kinds of expenditures, in order to discover which spending categories can be effective in stimulating economic activity. In this regard, Chapter 6 runs an extended model which replaces the overall spending variable by three spending categories: *i)* benefits (social security, retirement allowances, etc.); *ii)* wages and *iii)* defrayals (which includes defrayals *per se* and capital spending). Chapter 7 concludes with the main results found in the basic and in the extended models.

[12] See, for example, Perotti (2004); Caldara and Kamps (2008); Parkyn and Vehbi (2013) and Pereira and Wemans (2013).

CHAPTER 3: METHODOLOGY

This section presents an outline of the identification methodology of a structural vector autoregressive model, and its implied impulse-response functions, under the hypothesis of stability and stationarity. Stationarity permits the estimations of well-behaved impulse-responses with non-explosive confidence intervals. As stated in the previous chapter, structural IRFs are reliable as representing true exogenous shocks on any variable of a VAR system, as long as the identification procedure is credible. Still, the structural errors and structural IRFs are obtained implicitly by imposing an identification procedure that relates the forecasted errors of the reduced-form model with the structural errors yet to be discovered. Consider the k order vector $x = (x_1, x_2, \dots, x_k)'$ containing the endogenous variables of the model. In the classical econometric theory, the data generating process of the stable x vector can be expressed by Equation [1]:

$$x_t = v + \lambda(L)x_t + u_t$$
$$\lambda(L) = \sum_{i=1}^{p} \lambda_i L^i \qquad [1]$$

Where x is the k-order column vector of endogenous variables; v usually represents a k-order column vector for the constant, but could be expanded into a matrix to include other deterministic terms such as trend, seasonal dummies, exogenous breaks, etc.; the polynomial $\lambda(L)$ is a lag function where each element λ_i is a $(k \times k)$ matrix; u_t is a white noise k-order column vector [$E(u_t) = 0$; $E(u_t u'_t) = \Sigma_u$; $E(u_t u'_s) = 0 \; \forall \; s \neq t$] and Σ_u is assumed to be a positive semidefinite, symmetric and non-singular. Those assumptions permit the presence of cross-correlation between equations, but not serial correlation (across time).

If the premises of the autoregressive model are satisfied (i.e., stability, white-noise reduced-form residuals) the λ_i coefficients can be consistently estimated, for example, by ordinary least squares (OLS): the right-hand side of Equation [1] has only pre-determined variables; in other words, no endogenous variables to impair the consistency of the model. On the other hand, the coefficients of λ_i are not structural parameters either, since the identification strategy was not yet imposed on the model. That means that reduced-form models are good for making predictions, but cannot be used to drawn economic conclusions about the behavior of the system when faced by a shock. The reduced-form model does not capture the contemporaneous correlations in Eq. [1], which are hidden in the vector of forecasted errors. In Eq. [2] the implicit correlations are made explicit by the pre-multiplication of the reduced-form equation by the $[k \times k]$ matrix A, generating a equivalent model.

$$\begin{gathered} Ax_t = Av + A\lambda(L)x_t + B\varepsilon_t \\ Au_t = B\varepsilon_t \end{gathered} \qquad [2]$$

Again, matrix A describes the instant effects between the endogenous variables inside vector x. The representation in Equation [2] is known in the literature as the *AB model*.[13] Matrix A is what was called *structural matrix* in the introduction: it also transforms the system of Equation [1] into an equivalent system that has white-noise errors (ε) with unit variance and no cross-correlation ($\Sigma_\varepsilon = I$). The B matrix specifies the contemporaneous impact of the structural shocks on the reduced-form innovations. In most cases, matrix B is restricted to be diagonal – meaning that structural shocks have impact only on its own reduced-form innovation –, reducing the system to the *A model.*[14]

Thus, knowledge of matrix A is necessary to derive the structural model and its impulse-response functions. First, the reduced-form model gives the λ_i coefficients and the estimated residuals (u_i). Without the structural matrix, one can only extract reduced-form IRFs from the forecast errors. These errors are correlated (Σ_u is not diagonal), making untenable to use the concept of *ceteris paribus* to these shocks (a shock in one variable, keeping all others equal to zero). Furthermore, there isn't an automatic formula or algorithm to uncover the structural matrix, i.e., the A matrix is not unique. In fact, the most that can be done is to choose *one* matrix that has credible restrictions. If there are several potentially credible structural matrices, each will produce a distinct vector of structural errors (ε). There are several methods to identify A; all of them being a mix of estimations and underlying assumptions that should be consistent with the particular empirical application.

[13] Lütkepohl (2007, p. 364).
[14] Lütkepohl (2007, p. 358-362)

Before detailing the structural identification procedures, it might be profitable first to derive (theoretically) the concept of impulse-response functions directly from the equations above. The derivation follows a standard textbook exposition on the subject. The proper role of the structural matrix on the IRFs can be easily grasped afterwards. First, its necessary to introduced the concept of *companion matrix*: the companion transforms a VAR (p) model – p being the order of the polynomial λ (see Eq. [1] and [2]) into a VAR(1):

$$\boldsymbol{X}_t = \boldsymbol{v} + \boldsymbol{\lambda}\boldsymbol{X}_{t-1} + \boldsymbol{U}_t \qquad [3]$$

Where $\boldsymbol{\lambda}$ is now a $[k^2 \times k^2]$ matrix,

$$\boldsymbol{\lambda} = \begin{bmatrix} \lambda_1 & \lambda_2 & \cdots & \lambda_{p-1} & \lambda_p \\ I_K & 0 & \cdots & 0 & 0 \\ 0 & I_K & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & I_K & 0 \end{bmatrix}$$

And $\boldsymbol{X}_t$, $\boldsymbol{v}$ and $\boldsymbol{U}_t$ are $(Kp \times 1)$ vectors:

$$\boldsymbol{X}_t = \begin{bmatrix} x_t \\ x_{t-1} \\ \vdots \\ x_{t-p+2} \\ x_{t-p+1} \end{bmatrix}; \boldsymbol{v} = \begin{bmatrix} v \\ 0 \\ \vdots \\ 0 \end{bmatrix} \text{ and } \boldsymbol{U}_t = \begin{bmatrix} u_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

x_t, v and u_t are the $[k \times 1]$ vectors from Equation [1].

It should be noted that the system in Eq. [3] is equivalent to the system of Eq. [1]. The autoregressive model is stable if the eigenvalues of $\boldsymbol{\lambda}$ have modulus less than 1. This is equivalent to stating that $det[I_K - \boldsymbol{\lambda} z]$ is different from zero (non-singular) for $z \leq 1$, that is, the roots of the *reverse characteristic polynomial* given by the determinant are less than 1 in modulus.[15] The mean and the autocovariances are given by:

$$\boldsymbol{\mu} = E(Y) = \left(I_{Kp} - \boldsymbol{\lambda}\right)^{-1}\boldsymbol{v}$$

[15] See Lütepohl (2007, Ch. 2) or, for a simpler exposition, Enders (2015, Ch. 5)

$$\mathbf{\Gamma}_Y(h) = \sum_{i=0}^{\infty} \boldsymbol{\lambda}^{h+i} \mathbf{\Sigma}_U (\boldsymbol{\lambda}^i)'$$

And $\mathbf{\Sigma}_U = E(U_T U_t')$. It is possible to retrieve the original model operating with the $[k \times kp]$ matrix $J = [I_K \;\; : \;\; 0 \;\; : \;\; 0 \;\; \cdots \;\; : \;\; 0]$. Applying the J matrix to the vector of variables, errors, mean and autocovariances:

$$x_t = J\boldsymbol{X}_t$$
$$u_t = J\boldsymbol{U}_t$$
$$E(x) = \mu = J\boldsymbol{\mu}$$
$$\Gamma_x(h) = J\mathbf{\Gamma}_X(h)J'$$

The stability of the autoregressive model above means that the sequence $\boldsymbol{\lambda}^i$ $(i = 0,1,2, \ldots)$ is absolutely summable, i.e., that the infinite sum $\sum_{i=0}^{\infty} \boldsymbol{\lambda}^i U_{t-i}$ *exists in mean square*. Eq. [3] is, a well-defined stochastic process that can be represented as a uniquely moving-average (MA) process:

$$\boldsymbol{X_t} = \boldsymbol{\mu} + \sum_{i=0}^{\infty} \boldsymbol{\lambda}^i \boldsymbol{U}_{t-i}$$

Where $\boldsymbol{\mu} = (I_{Kp} - \boldsymbol{\lambda})^{-1} \boldsymbol{v}$. The distribution and joint distributions of x's are uniquely determined by the distribution of the u's processes, which can be retrieved operating with the J matrix:

$$\begin{aligned} x_t &= J\boldsymbol{\mu} + \sum_{i=0}^{\infty} J\boldsymbol{\lambda}^i J' J \boldsymbol{U}_{t-i} \\ &= \mu + \sum_{i=0}^{\infty} \Phi_i u_{t-i} \end{aligned} \qquad [4]$$

Where,[16]

[16] One could derive the MA form of the autoregressive process through the *lag operator* notation. See Lütkepohl (2007, Ch. 2). With a constant mean and autocovariances that depends not on *t* but only on the number of time periods (*h*) separating the two vectors (y_t vis-à-vis y_{t-h}), one can conclude that the stable VAR process is also stationary. *Wold*'s decomposition theorem states that any stationary process can be decomposed into two processes: a deterministic process and a MA stochastic process. Under fairly general conditions, every stationary, nondeterministic process can be approximated by a finite order VAR process. This gives good grounds to model macroeconomic series as vector autoregressive processes.

$$\Phi_i = J\boldsymbol{\lambda}_i J'$$
$$u_t = JU_t'$$
$$E(x_t) = \mu$$
$$\Gamma_x(h) = \sum_{i=0}^{\infty} \Phi_{h+i}\Sigma_u \Phi_i'$$

Because $\boldsymbol{\lambda}^i$ is absolutely summable, the same can be said about Φ_i. Also, it is possible to guarantee that Eq. [4] exists. In addition, the vector of coefficients Φ can be derived from $\boldsymbol{\lambda}$, if this matrix is known. The reduced-form estimation according to Eq. [3] gives the estimate of $\boldsymbol{\lambda}$ and, therefore, of Φ_i.

In fact, Eq. [4] actually is the impulse-response function representation of the reduced-form model in Eq. [3]. Each entry in the Φ_i matrix gives the response of one of the variables of the vector x, due to an innovation (that is, shock on the residual, u) occurred *i* periods in the past. For example, knowing that the $\Phi_{i,}$ is$[k \times k]$, and assuming that, say, $k = 3$, then the component $\Phi_{23,(4)}$ measures the impact on the second variable due to an innovation on the third, four periods behind (or the response four periods ahead from a shock at the present):[17]

$$\frac{\partial x_t}{\partial u_{t-i}} = \frac{\partial x_{t+i}}{\partial u_t} = \Phi_i$$
$$\frac{\partial x_{2,(t+4)}}{\partial u_{3,(4)}} = \Phi_{23,(4)} \qquad [5]$$

Once derived the concept of impulse-response functions, even though yet on its reduced-form representation, the identification problem of the structural model might become more clear: the idea of a *exogenous* innovation (see Eq. [4]) *i* periods behind (that is, a shock on one residual keeping all others equal to zero) to currently affect the vector of endogenous variables is very problematic, since the covariance matrix Σ_u is not diagonal (the contemporaneous shocks are correlated). Matrix *A* in Eq. [2] accomplished two purposes: it inserts contemporaneous effects and at the same time transforms the reduced-form errors into structural errors without instantaneous correlation with each other. In the following two forms

[17] That is, an entry of the matrix $\boldsymbol{\Phi}_i$ is given by the coefficient $\boldsymbol{\Phi}_{mn,(i)}$, where *m* and *n* specify the row and column location, respectively $(m, n = 1,2, \ldots, K)$.

of choosing A will be considered. Both can be classified as being structural identifications. The first is the recursive approach and the second is the structural identification *per se*.

The recursive approach is straightforward to implement. It consists in establishing a causal order between the variables. The identification is accomplished restricting matrix A to be a lower triangular with unitary main diagonal (define it as matrix A_R) and matrix B as diagonal. This is the Choleski decomposition. The equation $Au_t = B\varepsilon_t$ is often written as $B^{-1}Au_t = Cu_t = \varepsilon_t$, and C is also lower triangular. Out of the result that every non-singular symmetric matrix Σ (as Σ_u) can be decomposed in the form $\Sigma = PP'$ and defining D as a diagonal matrix with non-zero variables equal to $diag[P]$, and yet defining $WD = P$, W being lower triangular and $diag[W]$ equal to unity. It is possible to demonstrate that if $\Sigma = DD'$, then $A = W^{-1}$, that is, A is also a lower triangular with $diag[A]$ equal to unity. Both $diag[D]$ and $diag[P]$ are equal to the standard deviation of the structural errors. Ignoring for a moment the constant term of the model and imposing a lower triangular form on matrix A:

$$A_R = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ -\alpha_{21}^R & 1 & 0 & \cdots & 0 \\ -\alpha_{31}^R & -\alpha_{32}^R & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ -\alpha_{K1}^R & -\alpha_{K2}^R & \cdots & -\alpha_{K,K-1}^R & 1 \end{bmatrix} \qquad [6]$$

Appling A_R (as in Equation [2]) gives,

$$\begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ -\alpha_{21}^R & 1 & 0 & \cdots & 0 \\ -\alpha_{31}^R & -\alpha_{32}^R & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -\alpha_{K1}^R & -\alpha_{K2}^R & \cdots & -\alpha_{K,K-1}^R & 1 \end{bmatrix} \begin{bmatrix} x_{1,t} \\ x_{2,t} \\ x_{3,t} \\ \vdots \\ x_{K,t} \end{bmatrix} = A_0 \sum_{i=1}^{p} \lambda_i L^i \begin{bmatrix} x_{1,t} \\ x_{2,t} \\ x_{3,t} \\ \vdots \\ x_{K,t} \end{bmatrix} + B \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \vdots \\ \varepsilon_{K,t} \end{bmatrix}$$

The first row of the system of equations above, that defines the dynamics of the first variable of the x vector, shows that in the first equation there are no instantaneous variables on the right-hand side; the second equation contains only $x_{1,t}$; the third equation contains $x_{1,t}$ and $x_{2,t}$, and so on. Since the objective here is to study fiscal effects, it might be profitable to put the discussion into perspective. The simplest and more common autoregressive model in this subject is the three-variable model popularized by Blanchard and Perotti (2002), defined as:

$$x = \begin{bmatrix} g \\ y \\ \tau \end{bmatrix}$$

Where g is the measurement in real terms of government spending; y is the measurement of economic activity, usually given by the real GDP and τ is the measurement of government tax receipts. The recursive method imply the following relationship between reduced-form and structural errors:

$$A_R u_t = B\varepsilon_t$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -\alpha_{yg}^R & 1 & 0 \\ -\alpha_{\tau g}^R & -\alpha_{\tau y}^R & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^y \\ u_t^\tau \end{bmatrix} = B \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^\tau \end{bmatrix} \qquad [7]$$

Eq. [7] makes clear the causal ordering: the zeros above the main diagonal indicate that the first variable innovation, government spending (u^g), is the result of its own structural shock (ε^g); output innovation (u^y) responds to its own structural shock (ε^y) and also from spending innovation (u^g) – and ultimately from structural spending shocks; lastly, tax receipts innovations (u^τ) responds output and spending innovation, and ultimately to output and spending shocks. Thus $\alpha_{gy}^R = \alpha_{g\tau}^R = \alpha_{y\tau}^R = 0$ (as well as all components outside the main diagonal of matrix B). This particular decomposition imposes on the data a structure where spending is the *exogenous* component of the system, that is, receives no instantaneous influence of the other two variables. Output, receives shocks from spending, but does not suffer instantaneously from movements from tax receipts. The latter, the most endogenous, absorbs shocks from both spending and output. Even though the above ordering is very appealing – considering tax receipts responding instantaneously to economic activity and output being influenced by government spending – it's particularly problematic in the sense that it imposes a zero tax effect on output (the structural identification will correct this shortcoming). The empirical consequences of this imposition will become clear at Chapter 5. Finally, needless to say, the imposition of, for example, matrix A_R on the model restricts only the contemporaneous correlations: the system in Eq. [6]-[7] has a dynamic in which all variables affect all other variables through the autoregressive coefficients after the initial period.

From a strictly technical point of view – of the mechanics VARs – the ordering chosen in Eq. [7] can be altered to any other. Off course, the permutation would generate completely different sets of vectors of structural errors and, consequently, distinct sets of impulse-response functions. The fact of the matter is that every new ordering means a new matrix A and, thus, new interactions between the matrix and the estimated reduced-form coefficients (the structural autoregressive coefficients are the results of multiplication of the structural matrix with $\lambda(L)$); those interactions will also define the structural impulse-response functions that one should work with. Going back to the model's MA representation in Eq. [4], it is easy to show the moving-average representation in terms of structural errors using the Choleski decomposition ($\Sigma_u = PP'$). The concept of *inverse matrix* permits to write the following:

$$x_t = \mu + \sum_{i=0}^{\infty} \Phi_i P P^{-1} u_{t-i}$$
$$x_t = \mu + \sum_{i=0}^{\infty} \Theta_i \varepsilon_{t-i} \qquad [8]$$

Where,

$$\Theta_i = \Phi_i P$$
$$\varepsilon_t = P^{-1} u_t$$

In Eq. [8] the impulse-response coefficients give the response of vector x to structural shocks. Thus, the coefficients in Θ_i can be interpreted as the responses of each variable to shocks on any variable (including itself) – *ceteris paribus*. This is possible because the covariance matrix of the structural errors is an identity ($\Sigma_\varepsilon = I$). The standard deviations of ε are contained in $diag[B]$.

The second strategy of identification, the *structural approach*, accomplishes the derivation of structural errors by the imposition of values on matrices A and B, but not necessarily in a recursive way, giving the structural model a more flexible characteristic. First, the structural identification would "impose zeros" on certain components of matrices A and B – using economic theory, if possible. It's possible to achieve identification in this way by imposing enough zeros, and many applied works had done just that [Cavalcanti and Silva, 2010; Correia and Oliveira, 2013]. Second, a more complex identification procedure would impose other values. This is the strategy of, for example, Blanchard and Perotti (2002) – that besides imposing zeros in many entries of A – calculated, outside the autoregressive model itself, at least one of the parameters of the structural matrix: the output-elasticity of taxes (output-tax elasticity). This strategy permitted an extra parameter to be left free and at the same time that give the restricted parameter a reliable value. Finally, regarding again the first strategy of imposing zeros, it should be stressed again that the procedure should not be *ad hoc*: in macroeconomic quarterly data, Blanchard and Perotti (2002) argue for the first time that the institutional knowledge regarding government decision-making, would suggest that there is little probability that open and democratic governments can implement discretionary changes, due to innovation on tax receipts or business cycles, within the same quarter of the shock itself.

Yet, the crucial restriction in Blanchard and Perotti (2002) model remains the imposition of an external value on the output-tax elasticity ($\alpha_{\tau y}$) – the parameter that measures the contemporaneous effect of output on tax receipts. As previously stated, within the model itself, there is only two options: the imposition of $\alpha_{\tau y} = 0$ (highly implausible), or letting $\alpha_{\tau y}$ to be a free parameter and impose zero on another parameter. BP's strategy was to use outside information about the short-run value of the output-tax elasticity and restrict the structural matrix with it.[18] Peres (2006) calculated this parameter for the Brazilian economy, following BP, for the period 1994-2005, using quarterly data. Peres found a value for the output-tax elasticity very close to the BP's own calculations. The empirical models at Chapters 5 and 6 assume that Peres' value is reliable. The empirical models also use the institutional hypothesis of $\alpha_{gy} = \alpha_{g\tau} = 0$ (the inability of the government to respond contemporaneously to the economic environment). These three restrictions are sufficient to arrive at an exactly identified model. The reduced-form variance-covariance matrix Σ_u gives 6 [=$(k^2 + k)/2$] distinguished parameters that can be used to identify 6 unknowns: three from the main diagonal of matrix B (standard-deviations) and three from the structural matrix (α_{yg}, $\alpha_{g\tau}$ and $\alpha_{y\tau}$). The parameter $\alpha_{y\tau}$ is the tax-elasticity of output (contemporaneous impact of taxes on output) that was restricted to zero in the recursive identification (Eq. [7]).

[18] See BP's appendix for detail. To arrive at a reasonable value of $\alpha_{\tau y}$ is necessary to calculate the tax-base-elasticity of taxes and the output-elasticity of tax base, for each component of taxes. See Cohen and Folette (2000) and Giorno et al. (1995).

$$A_S u_t = B\varepsilon_t$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -\alpha_{yg}^S & 1 & -\alpha_{y\tau}^S \\ -\alpha_{\tau g}^S & -\boldsymbol{\alpha_{\tau y}^S} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^y \\ u_t^\tau \end{bmatrix} = \begin{bmatrix} \beta_{gg} & 0 & 0 \\ 0 & \beta_{yy} & 0 \\ 0 & 0 & \beta_{\tau\tau} \end{bmatrix} \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^\tau \end{bmatrix} \qquad [9]$$

All the zeros and the parameter $\boldsymbol{\alpha_{\tau y}}$ are restricted values. The key element of the structural matrix is the restricted parameter of the output-tax elasticity, which makes possible set the tax-output elasticity as a free parameter, to be estimated within the autoregressive model together with spending-output (α_{yg}) and spending-tax $(\alpha_{\tau g})$ elasticities. Again, structural identification generates different structural errors and coefficients in the same way that different orderings of the Choleski decomposition would. This can be seen in Eq. [8]: if one uses the matrix A_S, instead of the lower triangular matrix P, on the MA representation of the VAR model, one would get a vector of structural errors distinct of both the reduced-form errors and the structural errors derived from using P. In the application of the next two chapters, it will be possible to compare between the results of applying A_R and A_S. In Chapter 6, an extended model will be set forth in which the spending variable (g) is divided into 3 categories: benefits, wage spending and defrayals. At that point, extra assumptions will be needed to identify the structural model. Likewise, these extra assumption need to be credible in order not to fall into a *ad hoc* structural model. With economic theory and reliable assumptions, it is possible to extend the autoregressive model to any number of endogenous variables as long as one imposes the right number of restrictions demanded by the system to identify the relation $Au = B\varepsilon$.[19]

The structural framework outlined above within the three-variable model seems sufficient to give notion of the process of identification of a structural model. The procedure outlined in Eq. [1]-[6] is applicable, in theory, for any dimension of the vector x. Each additional variable in x will require additional restriction to identify structural impulse-response functions. The extended model of Chapter 6 will also rely on the external calculation of the output-tax elasticity, as well as in the institutional restrictions previously stated. New assumptions, however, will be needed there. It will be argued, for example, that the three

[19] The number of restriction is related to the dimension of the vector of endogenous variables, which defines the number of distinct values on the matrix of covariance of the reduced-form errors. It is possible to work with an overidentified model – when the number of restriction is greater than needed. This route is less appealing, though, because one wishes not to impose more restriction than necessary (in most applied work). An example of overidentified model with good theoretical foundations is Sims (1986).

categories may have a particular dynamics between themselves that already forces a pattern of response between each other. This will help to identify the larger model. These extra assumptions will require only small changes on structural model of Eq. [9] (besides the augmented dimension) so that it may be better to account for them appropriately in Chapter 6.

Finally, the econometric time-series theory outlined the procedures to achieve identification of a structural autoregressive model derived from an estimated reduced-form model. The theory suggested that the VAR derivation presupposes a vector of endogenous variables that is stationary. Most economic time-series, however, do have a positive time trend (se Figures in the next Chapter). The positive time trend could be the result of a unit-root process or a deterministic trend. This poses a problem to direct application of the aforementioned theory to the levels of macroeconomic data. The second section of Chapter 4 will show that unit-root tests, even those that account for structural breaks, do not give unambiguous evidence regarding the true data generating process of the time series under analysis here (spending, output and tax receipts). On other words, it is difficult to settle to question of whether the macroeconomic series are unit-root or trend-stationary processes. Each assumption (unit-root or deterministic trend) would require a different transformation procedure on the original variables. At the end of Chapter 4, an argument is made favoring the comparison between the two assumptions.

CHAPTER 4: DATA ANALYSIS

4.1 DATA DESCRIPTION

This section will give a brief description of the set of economic variables latter used in the estimation of the autoregressive model and its impulse-response functions. The impulse-responses will be the instrument used to assess the effects (dynamics) of the Brazilian fiscal policy. The basic model proposed by Blanchard and Perotti (2002) has three variables: two fiscal variables – government receipts and expenditures – and the economic output (GDP). The application of BP's model to the Brazilian case will require some accommodation, however. Next paragraph will present some comments about the some relevant attributes of the set of macroeconomic data to be used in the model. These comments will be important for an accurate interpretation of the results, after they are presented.

First, it is important to notice the major difference regarding the availability of Brazilian quarterly macroeconomic data in comparison with leading OECD countries. The sample sizes in these latter cases are simply too much more larger than samples from developing countries like Brazil. Brazilian National Accounts System makes available quarterly GDP data only from the first quarter of 1995 onwards This studies uses the complete set of GDP data available at the time, which goes from 1995 to the first quarter of 2015, totalizing 81 observations. Compare these numbers with the availability of quarterly macroeconomic data for the U.S. economy – that goes back to the 1950s –: more than 200 observations. A few other developed countries (United Kingdom, Canada, Australia and Germany, for example) have comparable time-series going back to the 1960s. Other group does have these macroeconomic dataset since the mid-1980s (e.g., New Zealand); and many, like Brazil, from the middle 1990s.

Regarding the state of Brazilian fiscal variables, the reality is a bit worse when compared with the National Accounts data. First, complete aggregated spending and receipts series for the consolidated government (federal, state and local governments) are completely absent.[20] There are, nonetheless, good and transparent fiscal data for the central government from the first month of 1997 onwards.[21] It is possible then to transform these monthly into quarterly data and end up with 73 observations.[22]

The alternative strategy of using unofficial data could do more harm than good: there is only one reliable approximation for the consolidated government's receipts [Dos Santos and Costa, 2008]; and only for the limited period of 1995:1-2007:4 (54 observations). Even if there were an analogous reliable source for the consolidated spending, the model would unduly suffer the problem of reduced degrees of freedom, which would potentially results in more inaccurate estimates. This is probably why Peres (2006; 2012) and Ilzetzki (2011) also chose to work with central government's data in similar setting. The IRFs estimates will be as accurate as the fiscal variables used in the model correlate with the (unavailable) consolidated government's fiscal variables.

Given the above caveats, it's now possible to start examining the actual data. Needless to say that the economic series analyzed in the following will compose the VAR models in this chapter and the next. First, the measure of economic activity, the output, is the Gross Domestic Product (GDP), made available by the Brazilian System of National Accounts – *Sistema de Contas Nacionais* (SCN) – from the *Instituto Brasileiro de Geografia e Estatística* (IBGE). SCN offers at least two GDP series: the nominal output and the real output at 1995:1 prices. One can, with these two series, derive the (accumulated) implicit deflator and use it to bring also the fiscal variables to 1995:1 prices.[23] Central government's receipts and expenditures at current values and monthly frequency is made available by Brazilian National Treasury – *Secretaria do Tesouro Nacional* (STN). Quarterly real values can be constructed by summing up monthly figures and then applying the same accumulated implicit GDP deflator derived from the GDP series. An essential feature to expand the basic model is the availability – in the STN database – of spending categories that sum up the overall spending;

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[20] As previously stated, there are estimations, at least for consolidated government receipts, for a small sample (1995-2007) made by Dos Santos and Costa (2008). Brazilian Central Bank also computes the consolidated government nominal and primary deficit (by variation of public debt). Cavalcanti and Silva (2010) and Mendonça *et al.* (2009) have worked with seemingly aggregated fiscal series for the consolidated government (unofficial) for a subset of the period 1995-2015.

[21] In Brazilian fiscal accounting, "central government" is the summation of three entities: *(i)* federal government's treasury, *(ii)* social security system and *(iii)* Brazilian Central Bank.

[22] One could use monthly data from the fiscal execution of the treasury, available from 1995 onwards to come back to 81 usable observations. This would partially preclude the measurement of output responses to benefit shocks. This will be carried out in the next chapter, in the expanded model, when the spending variable is divided into benefits, wage and defrayals.

[23] The Brazilian quarterly official GDP deflator series does not actually measure quarterly inflation, but the inflation of the current quarter in relation to the average price of the previous year. Dos Santos and Pires (2007) already pointed out this issue.

this makes relatively straightforward to expand the basic model into an expanded version substituting the spending categories for the overall expenditure. The basic model will be estimated in the next chapter while the expanded version will be estimated in Chapter 6.

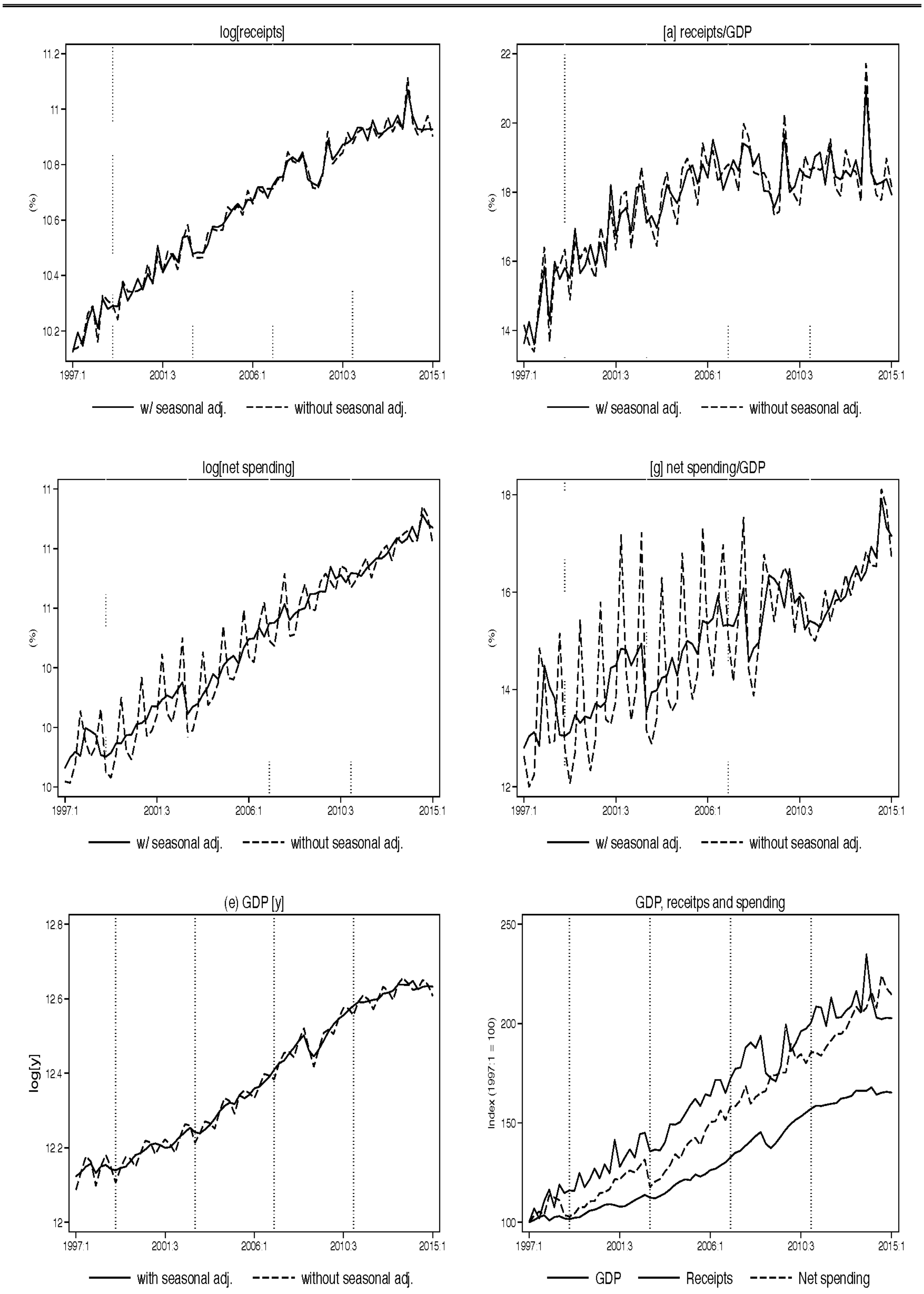

FIGURE [I-1] – GDP AND FISCAL VARIABLES.
Source: IBGE/STN.

Figure [I-1] gives the dynamics of the three main aggregate macroeconomic variables: central government's receipts, central government expenditures and real GDP, in panels *(a)*, *(c)* and *(e)*, respectively – in logarithmic transformations. The first two variables are also presented as share of GDP [panels *(b)* and *(d)*]. The solid lines represent seasonally adjusted series (ARIMA-X12 method) whole the dashed lines are the original series without adjustment; panel *(f)* gives the proper evolution of the seasonally adjusted real values of the three series, as indexes with 1997:1 = 100. For example, the values for 1997:2 in the last panel is given by summing the respective variable growth is 1997:2 with the previous value of 100, and so on. In all panels, the dotted grey vertical lines mark presidential mandates. Lastly, it is worthwhile to take into account the fact that all fiscal variables presented in Figure [I-1] are already net of transfers from the central government to state and local governments. These series are also used in the autoregressive models.

The period beginning in 1997:1 and ending in 2015:1 comprehends three presidential administrations and five mandates. It goes from the second half of the first term and all the second term of *Fernando Henrique Cardoso* – from 1997:1 to 2002:4 –; the first and seconds terms of *Luís Inácio Lula da Silva* – from 2003:1 to 2010:4 –; and the first term (and one quarter of the second) of Dilma Roussef – from 2011:1 to 2015:1. During the period, there was only one change party's change in the presidency, occurred when the Worker's Party won the 2002's general elections.

Table [I-1] gives summary growth rates of GDP, central government's receipts, spending and spending categories – the last divided into three: benefits, wage and defrayal spending. The growth rate of the Brazilian economy kept increasing from a low point in *FHC I* until the end of *Lula II*; but tem collapsed again during the last presidential mandate. The average growth rate of FHC I refers only to the last two years of the mandate; and is contaminated by the adjustments that hit the Brazilian economy during the 1998-99 years – when the consequences of the Asian and Russian crises were felt – inclusive the unwillingness of the rest of the world to finance Brazil's balance of payments deficits, forcing the country to advance in a couple of years the necessary reduction of the fiscal deficit and allow currency devaluation. In the following, FHC II also had to deal with an energy rationing (2001) and economic instability driven by 2002 presidential election and the threat of policy change if the (at the time) opposition party won the general elections. The opposition party did in fact won – worsening expectations in the short run (last quarter of 2002), especially regarding inflation, forcing the newly elected government to enact a tough fiscal adjustment in 2003. Afterwards, the economy resumed growth until hit by the global financial crisis of

2008-2009, entering recession in 2009. Recovery came in 2010 with a particularly high growth, but not sustainable. From 2011 onwards, one can verify a tendency of slowing growth that turned into recession from the last two quarters of 2014 onwards (when converted to annual growth rates).

TABLE [I-1] – RATES OF GROWTH (SIMPLE AVERAGE), BY PRESIDENTIAL TERMS.

Period	GDP	Receipts	Spending			
			Net	Benefits	Wage	Defrayal
Sample	2.94	6.14	5.17	6.45	3.37	8.28
FHC	2.35	9.77	5.59	6.06	6.06	7.15
FHC1	1.26	12.0	3.77	8.17	3.46	3.59
FHC2	2.83	8.82	6.39	5.14	7.20	8.71
LULA	4.11	5.28	5.03	7.42	2.99	7.82
LULA1	3.50	4.09	4.74	8.59	2.15	6.34
LULA2	4.72	6.47	5.31	6.25	3.82	9.30
DILMA	1.55	2.84	4.86	5.15	0.46	10.7

Source: IBGE/STN
Note: Average real growth rates of the seasonally adjusted series.

During the period 1997:1-2015:1 is substantial increase in the relative size of the central government to the overall economy. Figure [I-1] give spending and receipt as share of GDP in panels *(b)* and *(d)*. The average of both government spending/GDP and receipts/GDP ratios were approximately 14 percent. These ratios rose to about 18 percent by 2014-15. This increment was allowed by a rapid growth of the fiscal variables – well above the overall economy: the real receipts grew at a annualized rate of 6,14 percent while the spending ("Net" in Table [I-1]) grew by a average of 5,17 percent. At the same time, the economy grew at a rate of 2,94 percent. This average growth rate represented a real GDP increase of 65 percent; real receipt increase of 103 percent and real expenditures increase of 82 percent.[24]

One should notice that the spending series was named was always named as "Net spending" or "Net" in Figure [I-1] and Table [I-1]. The reason for this will be clear now: the definition of *net spending* subtracts from total spending residual types of spending such as: unemployment insurance, subsidies, *Bacen* expenditures and Treasury transfers to *Bacen*; these subtractions represent at most 8 percent of the total spending. The net series after those subtractions called *net spending* can then be divided into the three broad categories: benefits, wage and defrayals. Panels *(a)* and *(b)* of Figure [I-2] show the share of the so-called "net" and "residual" spending as shares of the overall spending. If the residuals are never more than

[24] See Chapters 6-8 of Giambiagi and Além (2010) for an account of the period 1995-2010 from a fiscal perspective.

7 or 8 percent of the overall spending, the net spending is never below 92 percent; thus, one can argue that the concept of net spending still is a good proxy to the movements of government expenditures. In the following, the terms "net spending", "spending" and "overall spending" should always be understood as be referring to the *net spending* series of Figures [I-1] and [I-2], especially in Chapters 5 and 6. The reason why total spending is discarded has to do with the identification process of the structural VAR model. This issue will be addressed again at the end of this section.

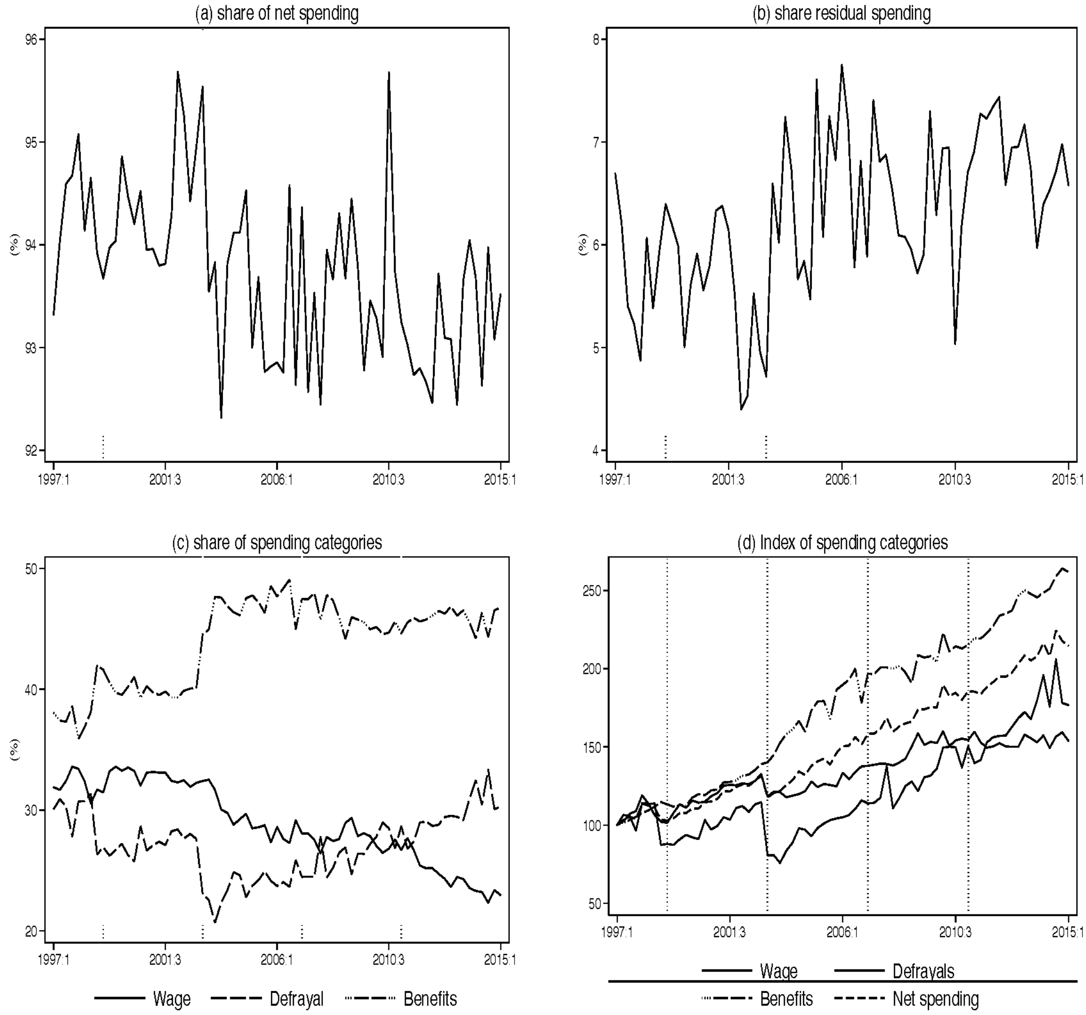

FIGURE [I-2] – SPENDING CATEGORIES.
Source: STN
Note: Seasonally adjusted variables.

Panel *(c)* gives benefits, wage and defrayals categories but this time as a share of the *net spending* series. Benefits expenditures have always been the single most important category and its share increase further, especially between 2002 and 2003. The increase in the share of benefits was carried out at the expense of defrayals; but since the 2003 adjustment, defrayals have gained participation at the expense of wage spending. Benefits' spending was 40% of spending in the beginning of the period. At the end, it was already at the 45% percent level; wage spending lost ground: going from 31% to 23%; defrayal spending begins and ends at roughly the same level (~ 30%). Panel *(d)* compares the evolution of government expenditures and its categories with the same methodology of panel *(f)* of Figure [I-1]: indexes with the real values of 1997:1 normalized to 100. The accumulated increase of benefits, wage and defrayal expenditures were 161, 53 and 76 percent, whereas the accumulated growth of the overall spending was about 100 percent. Its worthwhile to compare these results with the accumulated growth (just 65 percent) for the overall economy.

The panels *(c)* and *(d)* of Figure [I-2] helps to identify some patterns on the spending variables and its categories that should be taken into account in the future empirical analysis. First, there is the case of fiscal adjustments. Two large adjustments are visible by sigh: one between the third quarter of 1998 and the other from quarter of 1999 and the second between the third quarter of 2002 and the third quarter of 2003. A major characteristic of these fiscal adjustments are that they are heavily concentrated in defrayals: in the first adjustment, defrayals felt by more than 5 percentage points; in the second, it felt by more than 7 percentage points. In comparison to GDP, the falls were around one percentage point: slightly less for the first case and a bit more in the second case. After 2003, the defrayal category slowly recovered its share on spending – growing more than wage spending (in real terms).

Secondly, there is a tendency of the benefits category to ever taking a increasing share of government expenditures and also as a share of GDP. This process will be more or less automatic in the future, from the point of view of the executive power in light of the current legislation and demographics. Brazil is making a continuous transition to a new reality with a much higher workforce/retired ratio; meaning an increasing pressure in the social security system. However, even though there is a urgency to increase the correlations between contributions vs. benefits in the social security system, a comprehensive legislation is hard to accomplish: it can only be done by constitutional amendment with high political costs, even more so after two mild reforms (the first in FHC II and the second in Lula I) that did not resolve the problem.[25] An increasing share of benefits together with the fact that this category together with wage spending cannot be object of short-run fiscal adjustments – remember that benefits and wage spending are approximately 68% of the overall government expenditures –

[25] See Giambiagi and Além (Ch. 11, 2011) and Giambiagi and Tafner (2010) for description of the retirement and pensions expenditures and potential challenges for the Brazilian economy.

implies a interesting dynamics to defrayals, especially in the face adverse shocks. Even though the share of defrayals did not have a significant fall since 1997:1, the fact of the matter is that this category suffers strong reductions, both in real terms and in terms of share of GDP or spending, associated with fiscal crises or adjustments. This is easy to understand: what is been called "defrayals" is labeled, in federal government accounts as *other defrayal and capital expenditures*; this entry concentrated government investments and other defrayals with potentially high multipliers in comparison to benefits and wages spending. This constitutional rigidity, that imposes fiscal adjustments to be concentrated on defrayals, then, by definition imposes the adjustments to be concentrated on investments. The outcome is a adverse tradeoff: some episodes in the near past have imposed short-run fiscal cost to maintain macroeconomic stability; but the distribution of the federal government expenditures guarantees, unfortunately, that the cost will be concentrated on those expenditures with highest multipliers, which can reduced growth further. If the benefits' spending continues to grow at a rate higher than the overall economy and the overall government spending, this painful process of adjustment will be worsened in the future.

Finally, there is the issue of why a new concept of spending – *net spending* – was introduced in the first place. Also, the spending categories were defined in terms of this variable, and not in terms of federal government's total spending. The reason behind the construction of the new variable comes from the necessity of an accurate identification of the structural model of the next two chapters. Take the identification of the structural matrix in Eq. [9]. One of the assumptions there is that government spending does not respond contemporaneously to economic activity. This is actually false for some types of expenditures, particularly unemployment insurance. Taking out unemployment insurance of the overall spending, one makes the empirical credible by using actual variables coherent with the theoretical model. The other subcategories taken out comprehend such a small part of government spending and keeping them would force an extended model in Chapter 6 to add another endogenous variables with high costs in terms of degrees of freedom. Again, the *net spending* variable comprehends at least 92% of the total spending of the federal government.

Before estimating the actual models in the next two chapters, it's important to resolve an intermediary issue that did not receive the proper attention in the Brazilian literature: the investigation of the data generating process behind the output and all the fiscal variables mentioned in this section. Panels *(a)*, *(c)* and *(e)* of Figure [I-1] show the logarithmic transformation of the output and fiscal variables with a possible positive trend; and panel *(d)* of Figure [I-2] would suggest the same pattern for the spending categories. On the contrary, the chapter on methodology argued for the necessity of a stationary vector [of endogenous variables] in order to guarantee the stability of the model. Since the type of transformation to be imposed in each variable depends on it's DGP, a correct estimation of the VAR needs a complete investigation regarding the statistical nature of the variable's trends. Precise diagnostic would be impossible by a graphical inspection, requiring the use of formal tests – which will be carried out in the next section. From this point on, the total spending time-series is completely ignored and all references to government expenditures are related to *net spending* and its categories; even if this is not explicitly declared.

4.2 Unit Root

Again, the procure to uncover the true data generating process of the relevant variables at this point is equivalent to differentiating unit-root (UR) or stochastic-trend (ST) processes from trend-stationary (TS) processes. The statistical behavior of a time-series depends heavily on whether it is a stochastic-trend or a trend-stationary process, even though the two processes may be similar by pure visual inspection. The diagnostic will define the manner in which the time-series will be transformed before entering the empirical model and, thus, potentially having important consequences in terms of results. If the data is composed of stochastic-trend processes, the original series must be first differentiated and then be inserted in the model. On contrary, that is, when working with trend-stationary processes the required procedure is to de-trend the variable before inserting it into the model. Both of these transformations imply loss of information, each in a distinct way, potentially creating very distinct kinds of impulse-responses dynamics. In sum, the fact of the matter is that the same theoretical model – a autoregressive model with certain identification assumptions – might not yield so similar results if estimated twice – assuming different properties to the DGP in each estimation.

The visual inspection of Figures [I-1]-[I-2] above would favor the conclusion that output and the fiscal variables are all non-stationary. It seems that output and all the fiscal series do have a positive time-trend. It is well known that a unit-root process would also have a similar dynamics, especially in small samples. In theory, traditional unit-root test would be capable of separate these two processes. Table [I-2] gives the three of the most traditional unit-root tests available – the *Augmented Dickey-Fuller* (ADF), the *Phillips-Perron* (PP) and the *Dickey-Fuller Generalized Least Squares* (DF-GLS). The last one is a modified Dickey-Fuller test proposed by Elliot, Rothenberg and Stock (1996). The DF-GLS undergoes a GLS transformation prior to the actual estimation of the Dickey-Fuller regression; making possible the calculation, endogenously, of the optimal number o lags to enter the Dickey-Fuller regression – and thus consistently giving the white-noise residuals in a efficient way. On the contrary, the white-noise residuals of the ADF (a necessary condition for consistency) regression must be attained manually: one should add lags of the first difference of the dependent variable until the regression produces white-noise residuals. But this should be carried out with care, since irrelevant lags reduces the number of degrees of freedom that could cause efficiency problems, especially in small samples. Lastly, the Phillips-Perron test is robust to the presence of serial correlation, even though there are indications that ADF test performs better in small samples.[26]

In Table [I-2] the ADF, PP and DF-GLS tests are performed on the seasonally adjusted logarithmic transformation of output, government receipts, government spending, and the three government spending categories (benefits, wages and defrayals). In all cases, the null hypothesis is of unit-root against two alternatives, one at the time: first against trend-stationarity and then against mean-stationarity hypothesis. A mechanical analysis would probably lead a researcher to not to reject the null in the case of GDP. For government spending and receipts, the ADF and PP test have conflicting results: If more weight is given to PP's tests, one could reject the unit-root hypothesis in favor of trend-stationarity, especially because the PP test reject the null in these cases at 1 percent significance. Regarding the spending categories, wage spending seems to be the only variable with mild evidence of trend-stationarity (rejection of the null at 10 percent). It is unlikely that the times-series are mean-stationary in the first place.

The results of Table [I-2] suggest that even using a straightforward decision rule – the *t-statistic* of the autoregressive component (ρ) of the test regressions – in some cases one faces contradicting results. A thorough analysis would add more ambiguity. For instance, if one accepts the strong rejection of unit-root hypothesis, say, for the spending variable, by the PP test, its necessary to deal with the problem posed by the fact that the same test also did not reject the null for at least two of the spending categories. These results, in conjunction,

[26] See Enders (2015, Ch. 4).

represent a contradiction: a seemingly trend-stationary variable has portions that behave as unit-root processes (the unstable character of unit-root processes should dominate over stable trend-stationary ones). Another important feature of Table [I-2] is the fact that many cases where the null is not rejected the respective test regression shows an estimation of the autoregressive component (ρ) that is reasonable below unit. For example, the ADF and PP tests for the spending categories, in almost all cases, estimates $\rho < 0{,}8$; both tests puts $\rho < 0{,}9$ for the GDP series. This is evidence that the traditional tests do not posses the capacity of rejecting the null even though the autoregressive component is well below the unit-root value ($\rho = 1$), opening doubts that at least parts of the non-rejections might be riding trend-stationary series that in small samples behave similarly as unit-root processes.

TABLE [I-2] – UNIT-ROOT TESTS (ADF, PP AND DF-GLS).

Variables	DF-GLS	ADF		PP	
	[t-stat]	ρ	[t-stat]	ρ	[t-stat]
log[GDP]: *trend*	[-1.261]	0.858	[-2.585]	0.894	[-2.215]
log[GDP]: *drift*	[-0.648]	0.998	[-0.294]	0.998	[-0.293]
log[receipts]: *trend*	[-0.750]	0.684	[-2.488]	0.494	[-4.743]***
log[receipts]: *drift*	[0.244]	0.963	[-1.688]**	0.958	[-1.942]
log[net spending]: *trend*	[-3.050]*	0.619	[-3.335]*	0.552	[-4.466]***
log[net spending]: *drift*	[2.461]	0.995	[-0.324]	0.990	[-0.529]
log[benefits]: *trend*	[-1.620]	0.879	[-1.633]	0.799	[-2.260]
log[benefits]: *drift*	[0.427]	0.987	[-1.072]	0.987	[-1.167]
log[wage]: *trend*	[-1.638]	0.72	[-2.948]	0.707	[-3.460]*
log[wage]: *drift*	[0.983]	0.95	[-1.624]*	0.951	[-1.760]
log[defrayal]: *trend*	[-1.785]	0.782	[-2.694]	0.758	[-2.995]
log[defrayal]: *drift*	[0.617]	0.993	[-0.199]	0.976	[-0.364]

Source: author's calculation.

Note: The DF-GLS and ADF tests are estimated with the addition of lags (first difference of the dependent variable lagged from one period onwards as an explanatory variable of the regression) to achieve white-noise residuals. The DF-GLS statistics are associated with optimum lag choice according with the Ng-Perron *t*-statistic, estimated within the test itself. For example, the lag associated with *log[GDP]* (with trend) is 5. In almost all cases, the ADF lag choice (according to the BIC criteria) was 1. Complete results are available upon request.

There is yet another source that could invalidate the previously straightforward analysis: the potential presence of structural change on the data. It has been argued that stochastic-trend and trend-stationary processes can behave very similarly, making it difficult to separate on from the other. Structural change creates makes the process even harder, and also permitting mean-stationary processes behave like non-stationary ones. In a specific empirical application, separating what is trend-stationary, mean-stationary (these both with or without breaks) and unit-root processes may be far from an easy task. The traditional tests of Table [I-2], then, despite being well known in the literature and straightforward to apply, might be unreliable in some applications. Breaks could, and often do, bias the tests statistics towards not-rejecting the unit-root hypothesis when, in fact, the series are stationary (around the mean or trend).[27]

To overcome this problem, Perron (1989) developed probably the first unit-root test that is robust to structural breaks, by including an alternative hypothesis with an exogenous break. The test assumed that the econometrician *know* the break points *a priori*. Applying the test to U.S. macroeconomic variables, chose commonsensical dates as the 1929 crash and the 1973 oil price shock, showing the many variables, previously held as unit-root – as established by the work of Nelson and Plosser (1982) – were, in fact, trend-stationary processes. However, even choosing reasonable break points, the fact that the test would rely in *ad hoc* assumptions about the location of potential breaks is seen as a weakness, characterized by a high degree of subjectivity on empirical applications.

In order to avoid an arbitrary choice of the location of structural breaks, several endogenous-unit root tests were proposed. There is, for example, the tests developed by Zivot and Andrews (1992) that, building upon the contribution of Perron (1989), constructed a unit-root test where the location of the break is endogenously-chosen by an internal algorithm. The null hypothesis consists in a unit-root process with drift (and no break) while the alternative is a trend-stationary process with one break – whether on *(i)* the constant; *(ii)* on the time trend or *(iii)* both the constant and time-trend. The algorithm consists in running repetated regression with the break in each period and choosing the break point that gives the least favorable outcome for the null, i.e., it minimizes the *t-statistic* of the autoregressive component. Zivot-Andrews critical values are larger than Perron (1989) critical values, making it harder to reject the null hypothesis. When applied to the same set of macroeconomic variables of Nelson and Plosser (1982), Zivot and Andrews (1992) failed to rejected the unit-root hypothesis in some of the variables that Perron did previously reject; in other cases the rejection was reinforced.

Back in panel *(f)* of Figure [I-1], for example, it's possible to identify potential break points: there's the spending collapse near the last quarter of 2002 and (more or less) the third quarter of 2003, and the collapses of output and government receipts in result of the

[27] See Clemente *et al.* (1998).

international crisis in 2009. Panel *(d)* of Figure [I-2] shows the collapse of defrayals in the second-half of 1998 and again in 2003 (but also some sporadic spikes) and fall in wage spending across fiscal adjustment in 2003. Benefits' spending seems to be the smoothest of all series – with less obvious points that might be characterized as potential breaks. In Table [I-3], this visual inspection is formalized by the application of Zivot-Andrews test. The first characteristic of the endogenous-break test is that it gives different break points depending on which alternative hypothesis one is working with, that is, if one assumes the break on the constant, on the trend or both on the constant and the break. Usually, one should expect the breaks to be close together; but this is not a biding rule. For instance, for the output, each break-type has fallen in a different year with more than two years of difference between them. The complete opposition, the defrayal spending had all the break-types at the same year. The case of defrayals is, in fact, the most obvious case in which the endogenous breaks happen to be on the point one would probably choose by informal methods of inspection – by the degree of the fall during the fiscal adjustment in that year.

The endogenous test of Zivot and Andrews (1992) would alter previously held conclusions based on the traditional tests. A rigorous comparison between Tables [I-2] and [I-3] is possible in the comparison of the Zivot-Andrews results with those ADF, PP and DF-GLS results when the alternative hypothesis have a time-trend. The most striking result refers to defrayal spending: it seems that the presence of a break completely biased the previous results, now with a complete rejection of the null hypothesis; more evidence in the same direction is given for the overall spending. There is also mild evidence of trend-stationary on the cases of government receipts and wage spending, if one is willing to accept 10 percent significance levels. On the other hand, Table [I-3] gave more robustness to the previous findings regarding the output and benefits' spending, in which cases, there is no statistical sign of trend-stationarity – except for the low values of the estimated autoregressive coefficients. It is noticeable, however, that the benefits' *t-statistic* is slightly below the critical value necessary to reject the null at the 10 percent level.

The Zivot-Andrews test is an endogenous-break unit-root test. It takes into account series with one structural break. However, it is subjected to the same criticism (of biased results) if, in a particular application, a series has more than one structural break. To add robustness to the analysis, Table [I-4] exhibits the endogenous-break test of Clemente *et al.* (1998): this is also an endogenous-break test, but one which can bear two break instead of just one. As Zivot and Andrews (1992), Clemente test chooses the break point with an endogenous procedure choses the breaks that minimizes the *t-statistic* of the autoregressive component, i.e., chooses the breaks in order to be the least favorable for the null hypothesis. Notwithstanding, Clemente test should be not considered altogether superior to Zivot-Andrews: the first allows only break in the drift terms – as the traditional tests do – limiting the comparisons with the last only in this case. Clemente test should not be seen as a complete substitute for the previous one.

TABLE [I-3] – ZIVOT-ANDREWS UNIT-ROOT TEST (ONE STRUCTURAL BREAK).

Variables	break type	Date	[t-stat]	1%	5%	10%
log[GDP]	*Mean*	2006:3	[-3.567]	[-5.34]	[-4.80]	[-4.58]
log[GDP]	*Trend*	2012:2	[-2.970]	[-4.93]	[-4.42]	[-4.11]
log[GDP]	*Both*	2009:3	[-3.193]	[-5.57]	[-5.08]	[-4.82]
log[receipts]	*Mean*	2012:2	[-3.592]	[-5.34]	[-4.80]	[-4.58]
log[receipts]	*Trend*	2008:1	[-4.396]*	[-4.93]	[-4.42]	[-4.11]
log[receipts]	*Both*	2008:4	[-4.598]*	[-5.57]	[-5.08]	[-4.82]
log[net spending]	*Mean*	2005:4	[-5.359]**	[-5.34]	[-4.80]	[-4.58]
log[net spending]	*Trend*	1999:4	[-5.178]***	[-4.93]	[-4.42]	[-4.11]
log[net spending]	*Both*	2004:4	[-5.469]**	[-5.57]	[-5.08]	[-4.82]
log[benefits]	*Mean*	2003:3	[-4.356]	[-5.34]	[-4.80]	[-4.58]
log[benefits]	*Trend*	2006:2	[-3.515]	[-4.93]	[-4.42]	[-4.11]
log[benefits]	*Both*	2003:3	[-4.680]	[-5.57]	[-5.08]	[-4.82]
log[wage]	*Mean*	2011:3	[-4.233]	[-5.34]	[-4.80]	[-4.58]
log[wage]	*Trend*	2010:2	[-4.109]	[-4.93]	[-4.42]	[-4.11]
log[wage]	*Both*	2008:4	[-4.827]*	[-5.57]	[-5.08]	[-4.82]
log[defrayal]	*Mean*	2003:1	[-5.310]**	[-5.34]	[-4.80]	[-4.58]
log[defrayal]	*Trend*	2003:4	[-5.304]***	[-4.93]	[-4.42]	[-4.11]
log[defrayal]	*Both*	2003:1	[-6.833]***	[-5.57]	[-5.08]	[-4.82]

Source: author's calculation.
Note: (***) significant at 1 percent; (**) significant at 5 percent; (*) significant at 10 percent.

Another feature of the mechanics of the two-break test is that it can be constructed according to two alternative procedures. First, there is the *alternative outlier* (AO) method – that captures sudden changes – and second, the *innovative outlier* (IO) method – which captures gradual shifts. The first method has two steps: it estimates the residual from the regression of the original variables against a constant and two dummy variables; then, this residual is regressed against its own lag, k lags its first difference and h lags of the first difference of the dummies (same of the first regression). The second method is a one-step procedure: the time-series is regressed against its own lagged value, two pulse variable, two dummy variables and *k* lags of the first difference of the dummies. Theoretically, one cannot have expectations that both methods will yield the same break points.[28]

TABLE [I-4] – CLEMENTE *ET AL.* (1998) UNIT-ROOT TEST (TWO STRUCTURAL BREAKS).

Variable	type	1st break		2nd break		Unit-root	
		date	[t-stat]	date	[t-stat]	ρ	[t-stat]
log[GDP]	AO	2005:1	[10.06]***	2008:2	[8.969]***	0.828	[-2.803]
	IO	2003:3	[3.715]***	2008:4	[2.458]**	0.920	[-3.406]
log[receipts]	AO	2004:2	[13.20]***	2010:1	[6.728]***	0.679	[-3.961]
	IO	2003:3	[3.349]***	2009:2	[2.827]***	0.742	[-4.258]
log[net spending]	AO	2005:1	[12.17]***	2009:2	[8.252]***	0.747	[-3.369]
	IO	2003:2	[2.707]***	2008:3	[1.565]	0.894	[-2.451]
log[benefits]	AO	2004:1	[14.94]***	2009:2	[7.117]***	0.752	[-3.377]
	IO	2003:1	[2.192]**	2008:4	[1.469]	0.905	[-2.438]
log[wages]	AO	2005:2	[7.110]***	2008:1	[6.347]***	0.692	[-3.969]
	IO	2005:3	[2.279]**	2008:2	[0.739]	0.827	[-2.167]
log[defrayal]	AO	2005:4	[7.187]***	2009:1	[9.145]***	0.633	[-3.836]
	IO	2006:1	[2.531]**	2009:1	[2.436]**	0.712	[-3.432]

Source: Author's calculations.
Notes: I) (***) significant at 1 percent; (**) significant at 5 percent; (*) significant at 10 percent. II) *t-statistics* in brackets. III) Both the additive outlier (AO) and the innovative outlier (IO) methods were performed with maximum optimal lag of order 4; and the sample is trimmed by 15%. Critical value at 5 percent of significance is 5,49.

Table [I-4] gives the test statistics for both AO and IO methods. Roughly, it is possible to state that the breaks are located more or less near strategic positions: the first in the period between the 2003 fiscal adjustment and the beginning increasing of economic growth of the decade; and the second, during or after the financial crisis, that also marked the end of the high-growth period. Thus, two breaks seem to give a better picture of the events that hit the Brazilian economy during the 2000s. Almost all the structural breaks are statistically significant. As previously state, the alternative hypothesis of Clemente test is a mean-stationary process. The *t-statistics* of the ρ's, however, are never significant at the 5 percent level. A cold analysis of the stats would lead to the conclusion that all the times-series are stochastic-trend processes, contradicting Zivot-Andrews and the traditional tests of the two previous tables. The regressions, though, suffer from the same problem already identified in the ADF and PP tests: the autoregressive coefficients, even though accepting the null, are bellow unit by good margin: the most striking case is the estimated ρ for the defrayals, with a value of 0,63 (AO method). Receipts and wages also have $\rho < 0{,}7$. In all cases, the

[28] For a brief discussion and application of the unit-root tests of Zivot and Andrews (1992) and Clemente *et al.* (1998) see Baum (2005).

autoregressive estimates are always higher in the IO method. The only instances with $\rho > 0{,}9$ (still well below unit) are the IO methods for output and benefits spending – the two variables in which the null was also not rejected in Tables [I-2] and [I-3].

As this data analysis sections comes to an end, it's important to summarize the evidence found: Tables [I-2] to [I-4] (Section 4.2) performed unit-root tests on quarterly data of seasonally adjusted logarithmic transformations of the Brazilian output, [government's] spending and receipts and the spending's three categories (benefits, wages and defrayals) between the quarters 1997:1 and 2015:1. The accumulated evidence unfortunately does not give unambiguous direction regarding the true data generating process of the aforementioned macroeconomic variables. Even in the case of the Brazilian output, which could be regarded by a *t-statistic* evaluation as a stochastic-trend process by all the tests, exhibited estimated values for the autoregressive coefficient that were well below unit. Thus, by a cold analysis of the *t-statistic* it may be the case that the odds lean more to the hypothesis that the variables are unit-root processes – and thus requiring first-differentiation before entering into the VAR model. The hypothesis of trend-stationarity, though, can not be dismissed to easily; and there is genuine cases in which the null hypothesis of unit-root was rejected. A comprehensive approach will be adopted in the next chapter, to accommodate the evidence found here: instead of choosing between the two DGP hypothesis, the autoregressive model will be estimated twice; one time assuming that all variables are stochastic-trend processes and one time assuming that the variables are all trend-stationary. The comparison between the two models will give a better perception of the problem at hand, in the sense that if the two models generate very different impulse-response behavior for the same type of shock, this will reveal a real problem in not paying to much attention to the issue of DGP assumption. Finally, the evidence at the end of the investigation should be weighted by the fact that the actual data – as described in Section 4.1 – is limited, in the sense that the fiscal variables comprises only the federal government statistics (and not the consolidated summation of federal, state and local governments). This restricts an overall application of the results, i.e., it's conclusions should take into account that the evidence to be presented will be useful in so far as federal government's variables behave in a similar fashion in comparison with the consolidated government's fiscal variables.

CHAPTER 5: BASIC MODEL

This section takes the basic model sketched in the methodology and uses the data from the previous chapter to construct structural impulse-response functions in order to assess the impact of Brazilian fiscal policy on economic activity. The x vector (Eq. [1]) will be composed at this point of three variables: $x = (g, y, \tau)'$, as g represents government spending; y represents output and τ represents government receipts. Before the benchmark structural model *per se*, Section 5.1 will derive from a recursive model. On latter, on Section 5.2, the structural model is constructed assuming a specific value [$\alpha_{\tau y} = 2$] for the output-tax elasticity; a strategic parameter for the identification procedure. Section 5.3 will perform a sensitivity analysis on the restricted parameter $\alpha_{\tau y}$, trying values in the interval $0{,}5 \leq \alpha_{\tau y} \leq 3$. The value of $\alpha_{\tau y} = 2$ was estimated by Peres (2006), and it's near the estimation of Blanchard and Perotti (2002) for the same parameter with U.S. data. The sensitivity analysis on the output-tax elasticity is important because the importance of the parameter in the identification process; and the sensitivity test will permit discover the magnitude of the changes in the results coming from alternative values. This necessity is reinforced by the fact that Ilzetzki (2011) estimated a much smaller value for the Brazilian elasticity [$\alpha_{\tau y} = 0{,}75$]; Last section also tests values higher than $\alpha_{\tau y} = 2$ in order to uncover potential effects in the presence of a much more tax-driven fiscal policy in the future of the Brazilian economy.

It is known from the battery of unit-root tests of the previous chapter that is was not possible to establish for certain the true data generating process of the output and Brazilian fiscal variables. The last chapter ends establishing the following strategy: estimate the model twice, assuming two different DGP assumptions. First, assume that all variables are unit-root processes (requiring first differentiation); secondly, assume that all variable are trend-stationary (requiring de-trending). This procedure will show how serious it is if one doesn't take into account the problem of uncovering the true DGP, as previous studies have done. The requirement of the first assumption, first-differentiation, results in the vector: $\Delta x_t = (\Delta g, \Delta y, \Delta \tau)'$, where Δ represents the difference between the current value and one-lagged value.[29] Δx_t will be the actual vector to be used into the VAR model. The requirement to bring stability, using the second assumption, is to de-trend the x_t vector. A traditional de-trending procedure is to estimate the residual from the equation $\epsilon_t^x = x_t - c_0 - c_1 t = (\epsilon_t^g, \epsilon_t^y, \epsilon_t^\tau)'$.[30] In the latter case, ϵ_t^x will be the actual vector used into the second model. Making parallels between impulse-responses with the same identification strategy (e.g., within the recursive model) are comparisons between DGP assumptions; making comparisons between the recursive and the structural models are, on the other hand, comparisons between different identification strategies. The analogous of Eq. [1] after the two transformations procedures are given in Eq. [10.1] and [10.2], for the stochastic-trend and the trend-stationary models, respectively:

$$\Delta x_t = v + \lambda(L)\Delta x_t + u_t^{\Delta x} \quad [10.1]$$

$$\epsilon_t^x = v + \lambda(L)\epsilon_t^x + u_t^{\epsilon^x} \quad [10.2]$$

In the next two sections, the IRF presentation will obey a fixed organization. The figures will be divided in two blocks. Every shock will show the response in both DGP assumptions. The left side [panel *(a)*] will always exhibit the responses under unit-root the assumption, following transformations from Eq. [10.1] – the *stochastic-trend impulse-response functions* –; and the right side [panel *(b)*] will always exhibit the response under the assumption of trend-stationarity following transformations of Eq. [10.2] – the *trend-stationary impulse-response functions*. The first response type should be interpreted as the response in growth rates due to a one-unit increase in the growth of the shock variable while the second response type should be interpreted as the logarithm response to a one-unit increase on the logarithm of the shock variable, which is also a percentage point response to an one-percent increase in the shocked variable. The complete set of impulse-responses from the application of Eq. [10.1] and Eq. [10.2] are localized in Appendix I – Figures [I-3] to [I-16]. It should be stated that the reduced-form estimations of the aforementioned equations achieved optimal point with 2 lags, for both DGP assumptions, according to most information criteria (the only exception being the SBIC criterion, which chooses 1 lag). Estimating the model with just one lag creates auto-correlated residuals.

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[29] $\Delta x_t = x_t - x_{t-1} = (\Delta g, \Delta y, \Delta \tau)' = (g_t - g_{t-1}, y_t - y_{t-1}, \tau_t - \tau_{t-1})'$.

[30] $\epsilon_t^x = y_t - c_0 - c_1 t = (\epsilon_t^g, \epsilon_t^y, \epsilon_t^\tau)' = (g_t - c_{g0} - c_{g1} t, y_t - c_{y0} - c_{y1} t, \tau_t - c_{\tau 0} - c_{\tau 1} t)'$

5.1 RECURSIVE MODEL

The three-variable VAR model of fiscal policy was popularized in the seminal article of Blanchard and Perotti (2002). They estimated the effects of fiscal shocks – government spending and government taxes shocks – on output (and its components) for the US economy during the post-world war II period. They applied restrictions on the structural matrix using knowledge from institutional procedures of policy-making – specifically the slow dynamics of legislative bodies to reach decisions regarding fiscal policy – and external estimation of the output-elasticity of taxes. The restricted value imposed on the output-tax elasticity by BP is very close to the value estimated by Peres (2006) for the Brazilian economy, around 2 percent. Blanchard and Perotti found that government spending shocks (taxes) had positive (negative) and statistically significant effects on economic activity. These effects did not die out quickly, remaining with statistical significance even after four years after the initial shock.

But before estimating the structural model following Blanchard and Perotti, it may be profitable to consider a recursive approach to construct a preliminary set of impulse-responses. The recursive model is the simplest way to derived structural errors and impulse-responses functions, without any knowledge of contemporaneous correlations besides a basic intuition regarding the order in which the variables impact one-another. This order may have some economic theory behind it, as is the case of the ordering to be used next. In addition, Cavalcanti and Silva (2010) had used a recursive model to derive their benchmark results. Estimating the recursive model may provide a good base of comparison for the structural model (the recursive model estimates endogenously a value for the output-tax elasticity); and, as collateral, may serve to compare the present data application with that of Cavalcanti and Silva.

By the discussion presented in the chapter on methodology, the recursive model sets an order of contemporaneous impact between the endogenous variables. In the three endogenous variable model, it goes from the first variable, the more exogenous, i.e., the one that doesn't suffer impact from any but at the same time impacts all the other variables, to the second – that suffers impact from the first and impacts all the other except the first –, to the third, that suffers contemporaneous impact from the previous two and doesn't impact any variable. The idea is the same if the model is expanded to add more endogenous variables. The description in the methodology purposefully used the actual ordering most indicated in an empirical application of fiscal policy: spending first, output as second and tax receipts at last. In the following, it will be clear that the recursive ordering can be interpreted as already containing part of the theoretical foundations of the structural model – regarding the institutions behind the decision-making process to alter the fiscal policy –; but which, at the same time, shows that the structural identification is superior.

Table [I-5] gives estimation[31] of the parameters of the structural matrix of the recursive model, applying Brazilian data to Eq. [7]. Note that on the structural matrix, the parameters above the main diagonal of the structural matrix are restricted to zero. These restrictions establish the recursive order and guarantee the exact-identification, since the reduced-form covariance matrix has only six distinct parameters (requiring the three restrictions of the structural matrix, besides all the restrictions on the off-diagonal elements of the B matrix). Thus, only the α's below the main diagonal of the A_R matrix are estimated parameters; the others are restricted to zero. The table below does the estimation under the two DGP assumptions.

Again, the parameters of the structural matrices in both columns (stochastic-trend and trend-stationarity) should be understood as elasticities. The spending-output elasticities (α_{yg}) and the spending-tax elasticities ($\alpha_{\tau g}$) are statistically significant – the α_{yg} parameters at the 5 percent level and the $\alpha_{\tau g}$ parameter at the 1 percent level – and with the expected signs. Also, first-mentioned parameter has a small value, i.e., the spending impact on output weak, relatively to the spending impact on tax receipts. Naturally, the spending shock does not cause the receipts to growth in order to finance the expenditures (the spending shock is deficit-driven). The output-tax elasticities, on the other hand, are statistically insignificant, well below the benchmark value to be used latter [$\alpha_{\tau y} = 2$] and calculated by Peres (2006) – and even below the value of Ilzetzki (2011) [$\alpha_{\tau y} = 0{,}75$]. This feature will have important implications for the tax shocks. All those features are remarkably true for both DGP assumptions, with the trend-stationary model having slightly weaker parameters, except in the case of $\alpha_{\tau y}$, in which case the smaller value belongs to the stochastic-trend assumption.

Figure [I-3] gives the responses to spending shocks. Spending own responses and also the tax receipts responses are very significant at impact – as already indicated by Equations in Table [I-5]. In the stochastic-trend model, spending and receipts responses have rebounds at the first quarter after the shock (significant in the case of the spending response) but not strong enough to cancel the initial positive responses; the responses are more smooth for the

[31] By Log-likelihood.

trend-stationary model. In both DGP assumptions, there is a positive dynamic response of output, but in neither case they are significant, even on impact. It's possible to argue that maybe the trend-stationary case has more persistent responses: this is factually true for the spending response; for the other two, a categorical affirmation cannot due to the presence of large confidence intervals.

The responses to a tax shock are given in Figure [I-4]. It is worthwhile the comparison between the spending response here and the tax response in Figure [I-3]: while a spending shock is partially financed by increasing taxes, a tax shock doesn't generate significant spending responses. One could argue that the result is partially the outcome of the recursive ordering (zero tax-spending elasticity, by construction); however, in both DGP assumptions, the following responses are near zero or negative – the response is negative and statistically significant after to quarter under the trend-stationary assumption. Tax own responses are statistically significant with positive response at the impact, but without persistent, converging rapidly to zero (the ST case having a negative rebound at the first quarter before the convergence). Finally, there is no significant output response to tax shocks on the recursive model.

TABLE [I-5] – STRUCTURAL MATRIX ESTIMATION (RECURSIVE IDENTIFICATION).

	STOCHASTIC TREND	DETERMINISTIC TREND
α_{gy}	-0.096 [0.039]**	-0.090 [0.039]**
$\alpha_{g\tau}$	-0.384 [0.145]***	-0.320 [0.145]**
$\alpha_{\tau y}$	-0.407 [0.422]	-0.527 [0.427]
β_{gg}	0.028 [0.003]***	0.025 [0.002]***
β_{yy}	0.009 [0.001]***	0.008 [0.007]***
$\beta_{\tau\tau}$	0.033 [0.003]***	0.029 [0.002]***

Source: Author's calculation.

Figure [I-5] gives the last group of responses of recursive model: the impulse-responses from output shocks. By construction, the impact spending response is zero; and it's not significant afterwards. The impact tax response is free by construction, with magnitude specified by the parameter $\alpha_{\tau y}$, being positive even though not significant. In both DGP assumptions, the response attains the maximum value at the first quarter after the impact and at that point is statistically significant (under trend-stationarity, the response at the second quarter is marginally significant). Surprisingly, the evidence suggests the presence of a counter-cyclical fiscal policy that contradicts earlier findings in the empirical literature. Latter on, it will become clear that this conclusion is not sensitive to the identification strategy. Finally, the output response to it's own shocks are given in the last row of Figure [I-5]. Here, the trend-stationary model undoubtedly generates more persistent responses: while in the stochastic case the business cycle is statistically is already marginally significant at the first quarter, in the deterministic case it lasts being significant yet at the third quarter.

In sum, the impulse-responses revealed three features of the recursive model: first, that economic activity does not respond significantly to fiscal signals, whether coming from spending or tax receipts (in other words, fiscal policy is ineffective); second, that tax receipts innovations do not generate significant spending response in the same direction – in fact, in the trend-stationary model, there is a negative spending response; and third, that the output shock causes fiscal responses such that suggests counter-cyclical policy – characterized by weak spending response and a significant and positive tax receipts response in the quarter following the initial shock. The first feature agrees more or less with Cavalcanti and Silva (2010) in the sense that the latter also estimated impulse-responses with large confidence intervals, characteristic of ineffective fiscal policy. On the other hand, the previous results disagree with them on the counter-cyclicality and also on the sensitivity of the spending variable to relaxations of the budget constraint (increase in receipts, for example).

5.2 Structural model

In this section, instead of letting the output-tax elasticity as a free parameter to be estimated within the VAR model itself, the identification procedure here will use Peres' (2006) calculation of the parameter and impose it on the structural matrix. This makes the structural identification close enough to BP's model. In order to maintain a exactly identified model, that is, keeping the number of restrictions at the minimum, the outside addition information from Peres will open another entry of the structural matrix to be a free. In the recursive model, there are three parameters that were set to zero: α_{gy}, $\alpha_{g\tau}$ and $\alpha_{y\tau}$ (see Eq. [9]). Of these, only the tax-output elasticity [$\alpha_{y\tau}$] was restricted without theoretical foundation – and simply because the recursive structure required it to be so. Regarding the other two elasticities, it can be reasonable argued, as will be in the following, that they must have zero values [$\alpha_{gy} = \alpha_{g\tau} = 0$]. These restrictions are relying on the assumption that government spending does not response quickly, because of the very institutional processes of constitutional decision-making governments – given the high-frequency nature of the dataset.

Accordingly, the theoretical foundation of imposing a zero restriction on the spending responses to economic activity and to tax receipts innovations – the output-spending and the tax-spending elasticities, respectively – is more farfetched than the earlier *ad hoc* structure of the recursive model: Blanchard and Perotti (2002) argues that countries like the United States, for example, there is a institutionalized decision-making process in which changing government expenditures is time-consuming – a characteristic of constitutional democratic governments. In fact, the legislative bodies must approve the annual spending policy of the executive branch of the government in advance (that is, the annual budget) and even sensible changes during the year due to new environments have to pass through congress. In Brazil (as in the U.S.), this requires procedures and debates in two legislative bodies (chamber of deputies and the senate). Combining with this the high-frequency nature of the macroeconomic data (quarterly national accounts) in the framework of autoregressive models, it is now easy to accept the supposition that government authorities do not possess the capacity of accumulate information, digest it and act upon it, responding to economic shock within a quarter, the assumption used to set $\alpha_{gy} = \alpha_{g\tau} = 0$. Within such a narrow window opportunity, one might even concede that it is in the power of the executive branch to alter and change part of the spending policy without the consent of the legislative bodies, but still, it's remotely possible that the government can act fast enough: even the current national accounts are not available to policymakers: at most, policymakers would have to interpret economic dynamics based upon monthly proxies of the overall economic activity; but there is no evidence that coherent policy is derived from such data.[32]

In Table [I-5] it was shown that the estimation of the recursive model implied a low value for the output-tax elasticity, below $\alpha_{y\tau} = 0{,}5$. This is less than 25% the $\alpha_{y\tau} \simeq 2$ of

[32] This assumption is common in many applied structural models. See Fatás and Mihov (2001), Perotti (2004) and Parkyn and Vehbi (2013).

Peres (2006)[33] and Blanchard and Perotti (2002)[34] and even smaller than the value found by Ilzetzki (2011)[35] [$\alpha_{y\tau} = 0{,}75$]. According to Perotti (2004),[36] there are countries with high output-tax elasticity such as United States and Canada; and others with low elasticities like United Kingdom, Australia and Germany. Parkyn and Vehbi (2013)[37] also attributed a low elasticity value for New Zealand [$\alpha_{y\tau} \simeq 1$]. Naturally, the imposition of another value for the elasticity, a high value, is expected to alter somewhat all other parameter of the log-likelihood estimation of the structural matrix, besides the calculation of the new parameter. This certainly will also bring meaningful changes to the structural impulse-response functions.

TABLE [I-6] – STRUCTURAL MATRIX ESTIMATION (STRUCTURAL IDENTIFICATION)

	STOCHASTIC TREND	DETERMINISTIC TREND
α_{gy}	-0.153 [0.050]***	-0.134 [0.474]***
$\alpha_{g\tau}$	-0.230 [0.153]	-0.187 [0.151]
$\alpha_{\tau y}$	-2	-2
$\alpha_{y\tau}$	0.135 [0.045]***	0.121 [0.043]***
β_{gg}	0.028 [0.002]***	0.025 [0.002]***
β_{yy}	0.011 [0.001]***	0.009 [0.001]***
$\beta_{\tau\tau}$	0.036 [0.003]***	0.032 [0.003]***

Source: author's calculations.

Table [I-6] gives the log-likelihood estimations of the theoretical structural matrix put forth in Eq. [9]. In comparison to Table [I-5], the structural estimation in the table below has an extra estimated parameter [$\alpha_{y\tau}$] while the output-tax elasticity is now a restricted value [$\alpha_{y\tau} = 2$] (again, approximately four times greater than estimations from Table [I-5]); but as before, the two models (stochastic-trend and deterministic-trend) have coefficients of the same order of magnitude. As expected, restriction of $\alpha_{y\tau}$ resulted in changes on the estimated

[33] For the 1995-2005 period.
[34] For the 1947-1997 period.
[35] For the 1997-2009 period.
[36] Roughly for the 1960-2001 period (depending on the country).
[37] For the 1983-2010 period.

values of the remaining parameters: first, the spending-output elasticity $[\alpha_{gy}]$ augmented substantially and also is statistically significant at the 1 percent level; on the contrary direction, there's the spending-tax elasticity $[\alpha_{g\tau}]$ that now does not have statistical significance by a combination of reduced magnitude and higher standard deviation in relation to the values from the previous table. Lastly, there is the new parameter $[\alpha_{\tau y}]$: it is precisely estimated, being statistically significant at the 1 percent level. The positive value in the tables implies that a positive shock on tax receipts is associated with a *negative* impact output response, as would be expected. In sum, the high output-tax elasticity is related with negative tax-output and stronger (positive) spending-output elasticities. The impulse-responses of the structural model should be expected to generated stronger output-response due to spending shocks and potentially a negative response to tax receipts shocks.

The structural IRFs are given in Figures [I-6]-[I-8] in appendix I. Figure [I-6] exhibits the impulse-responses from a spending shock. Even though that's a different identification, the responses are basically the same from Figure [I-3]. There is no new information to be added to the previous analysis. The structural identification only brought new behaviors to the system's responses to tax and output innovations.

Figure [I-7] presents the system's responses to tax shocks. First, the spending and tax receipts own responses are also very similar to the recursive model (Figure [I-4]). Differences between identification strategies become relevant when comparing the output responses. This is not by accident: the structural identification allowed the inclusion of a new free parameter that precisely measures the instant impact of tax innovations on output. The new impulse-responses have a completely different behavior: under stochastic-trend assumption, the response is strongly negative and significant at the impact while in under trend-stationarity, the negative response is significant at impact and is marginally significant at the first quarter. It doesn't even makes sense to compare the recursive and the structural output responses: the output response at the impact of the recursive model is zero by construction and in the first and second quarter are even positive, even though without economic significance given it's proximity to zero. In the next section, the sensitivity analysis will allow comparisons between different identifications for the output-tax elasticity.

Figure [I-8] shows the system's responses to an output structural innovation. The spending response continues to be insignificant as the contemporaneous impact of output on that variable continues to be zero by construction (there are some small changes in the magnitudes of the responses in both DGP assumptions, but there are great similarities between the behaviors of the structural and recursive responses). On the contrary, tax responses are dramatically changed: now, the impact response, in the stochastic-trend assumption, is strongly significant; under trend-stationarity the response is positive and only marginally significant due to large confidence intervals at the first quarters. The shape these structural the responses are also quite different; with maximum response happening already at impact – and not after one quarter as in the recursive model. The impact response of the structural model is 4,5 and 3,5 times greater – under stochastic-trend and deterministic-trend assumptions, respectively – than the recursive responses. These values imply, that under the structural approach, if it has been corrected specified, the Brazilian economy has a much higher capacity of generate tax receipts in the short-run. About comparison between responses apart from the impact shock, it may be more advisable to use cumulated impulse-response functions (CIRFs): cumulated impulse-responses sum up present and past values of responses up to the current point and thus generating a much stable function.[38] The comparison between recursive and structural CIRFs show that the structural responses stabilize at the fifth (ST model) and the third (TS model) quarters with a value more or less 30 percent higher than the recursive CIRFs. Finally, remains the responses of output to its own shock. Under both DGP assumptions the structural model reduces the magnitude of the shock, in general keeping the structural CIRFs about 10 percent lower than the recursive CIRFs; under trend-stationarity the structural model also reduces the statistical significance of the impulse-response from three quarters after the initial shock to two; and even so with the response of the structural model being only marginally significant. Both identification strategies using the stochastic-trend model generate impulse-responses significant only at the impact.

5.3 Sensitivity analysis

The analysis, so far, have shown that the effects of fiscal policy on output (and the effects of output on the fiscal variables) can be influenced by the data generating process

[38] Accumulated impulse-response function is defined as the summation of the current and all previous responses until a particular point in time. For example, the fourth period accumulated impulse-response of output to a tax shock is the summation of the relevant impulse-response of the fourth, third, second, first and impact impulse-responses. The statistics and graphs of accumulated responses are available upon request.

assumption of the econometrician. The comparison between impulse-response functions generated by each DGP assumptions revealed cases where the IRF behavior can be quite different. There a tendency for the trend-stationary IRFs to be a bit more persistent, especially for the business-cycle response. Additionally, the two previous sections have shown that the identification of the structural model changed responses, especially the output response to tax shock, in a fundamental way. This section will test if particular structural identification of Section 5.2 [$\alpha_{\tau y}$] is driving these changes, and which interval of values for the output-tax elasticity can generate similar results. The expectation, by the endogenous estimation of $\alpha_{\tau y}$ in the recursive model is in the affirmative.

The test will be thus a sensitivity analysis on the coefficient $\alpha_{\tau y}$. The procedure will be to assume alternative, and reasonable, values for this parameter. There are two indication of possible values: Peres (2006) [$\alpha_{\tau y} \simeq 2$] and Ilzetzki (2011) [$\alpha_{\tau y} \simeq 0{,}75$] estimations. The analysis below will test the latter value for $\alpha_{\tau y}$, as well as low values around it [$\alpha_{\tau y} = 0{,}5$; $\alpha_{\tau y} = 1$]. The last value to be tested will be the extreme case where $\alpha_{\tau y} = 3$. This extremely high output-tax elasticity model should be seem as generating possible dynamics from a hypothetical policy change with the objective of reallocating more of future growth to the Brazilian government sector.

Imagining higher output-tax elasticity in the future, comparing with the recent past, is not an unreasonable scenario – especially if one considers how fiscal variables have been evolving during the last two decades. During the period, there has been a increasing pressure for more public services (education, health, social expenditures, etc.) that did not result in explosive debt because of a equivalent and rapid increase of the tax burden (see Figure [I-1]). Spending contractions were only temporary and with the objective of recovering macroeconomic stability on the short run. Additionally, there is an adverse pattern on federal spending in which the obligatory expenditures, especially social security, tend to rise more or less automatically (increasing its share of the overall spending) in the absence of reforms. Thus, the tendency and structure of federal expenditures precludes, or at least difficult, controlling public spending. Thus, future fiscal adjustments will probably have two features: *i)* if generating spending reductions at all, they will rely on defrayal spending reductions, and *ii)* the adjustment will be heavily concentrated rather on tax increases. Possibly, for example, the central authorities will at some point perform a fiscal adjustment in order to reintroduce fiscal surpluses – a policy objective abandoned in 2014. Attaining such a policy in the year 2015 proved to be quite difficult: reducing spending was not possible, with strong opposition of sector of civil society and even the legislative bodies. The alternative, in the short-term, without serious spending reductions, is to increase the tax burden. It is reasonable to suppose, accordingly, that the increase in tax will affect not only the mean tax rate but also marginal tax rates in order to a larger share of future economic growth to be accrued to the government sector. Thus, the future might be one where the output-tax elasticity may be even higher than the recent past, as calculated by Peres (2006).[39]

Table [I-7A] and [I-7B] give estimations of the structural matrices in the same way as Table [I-6], but for the selected values of output-tax elasticity [$\alpha_{\tau y}$]: each column is the log-likelihood estimation assuming $\alpha_{\tau y}$ values in the interval $[0{,}5 < \alpha_{\tau y} < 3]$. Table [I-7A] exhibits the estimated parameters under the stochastic-trend hypothesis while Table [I-7B] gives the analogous results for trend-stationarity. Comparisons between columns of each table give interesting insights. First, there is a positive correlation between output-tax [$\alpha_{\tau y}$] and spending-output [α_{yg}] elasticities: a higher contemporaneous impact of output on taxes is associated with a higher impact of government expenditures on output. Second, the relationship is inversed between the output-tax and the spending-tax [$\alpha_{\tau g}$] elasticities: the higher the first, the smaller will be the contemporaneous impact of the expenditures on tax receipts. If fact, the spending-tax elasticity remains with statistical significance only for small values of output-tax elasticity [$\alpha_{\tau y} \leq 1$]; thirdly, and foremost, there is the positive correlation between the contemporaneous output-tax and tax-output [$\alpha_{y\tau}$] elasticity: a higher $\alpha_{\tau y}$ is also associated with a higher power of tax to instantaneously affect economic activity. This correlation is the reason why the change of fixing a single parameter in the passage from the recursive to the structural model changed the output response to tax innovations so decidedly: the model with the lowest output-tax elasticity [$\alpha_{\tau y} = 0{,}5$] has its value very near the estimated value from the recursive model. It's clear from the two tables below that this low elasticity value implies a very small and insignificant value for the tax-output elasticity. On the other hand, only the high values for $\alpha_{\tau y}$ are capable of generating strong and statistical significant values for the parameter $\alpha_{y\tau}$ - the most important parameter for the output response to tax shock found on the structural model. The third relationship, thus, revel a important tradeoff: policies that change the output-tax elasticity (to accrue more of the economic growth to the government sector) will imply a stronger fiscal tax policy, in the

[39]Spending demands have been growing since 1988 constitution. Government receipts growth rate well above output's growth is most likely explained by a combination of average and marginal tax increases. See Giambiagi (2008) for a description of fiscal policy between 1991 and 2008.

sense that tax increases (decreases) will have strong negative (positive) effects on output. Changing $\alpha_{\tau y}$ from 2 to 3 augments $\alpha_{y\tau}$ by 68% and 75%, under the stochastic-trend and trend-stationary hypothesis, respectively.

Figures [I-9] and [I-10] compares the impulse-response functions under the alternative values of output-tax elasticity. Figure [I-9] gives the impulse-responses of tax receipts shocks and Figure [I-10] exhibits the responses to output shocks. IRFs from spending shocks were omitted due to the fact that they are largely the same as those from Section 4.2. The comparison figures have the same structure as before – separating stochastic-trend and trend-stationary models in different panels. Also, the same pattern is used in both figures to differentiate between the distinctive models: dashed light-grey lines represent the recursive model; dashed dark-grey lines give the structural response of modeling with $\alpha_{\tau y} = 0{,}5$; dashed black lines give the model with $\alpha_{\tau y} = 0{,}75$; solid light-red lines give impulse-responses of $\alpha_{\tau y} = 1$; solid dark-red lines, $\alpha_{\tau y} = 2$ and finally solid black lines give IRFs derived from the modeling with $\alpha_{\tau y} = 3$.

TABLE [I-7A] –SENSITIVITY ANALYSIS ON $\alpha_{\tau y}$ (STOCHASTIC TREND ASSUMPTION)

	$\alpha_{\tau y} = 0.5$	$\alpha_{\tau y} = 0.75$	$\alpha_{\tau y} = 1$	$\alpha_{\tau y} = 2$	$\alpha_{\tau y} = 3$
α_{gy}	0.100 [0.042]**	-0.108 [0.043]**	-0.117 [0.044]***	-0.153 [0.050]***	-0.193 [0.059]***
$\alpha_{g\tau}$	-0.375 [0.140]***	-0.351 [0.140]**	-0.327 [0.142]**	-0.230 [0.153]	-0.134 [0.173]
$\alpha_{\tau y}$	-0.5	-0.75	-1	-2	-3
$\alpha_{y\tau}$	0.008 [0.034]	0.028 [0.035]	0.049 [0.036]	0.135 [0.045]***	0.227 [0.062]***
β_{gg}	0.028 [0.002]***	0.028 [0.002]***	0.028 [0.002]***	0.028 [0.002]***	0.028 [0.002]***
β_{yy}	0.009 [0.001]***	0.010 [0.001]***	0.010 [0.001]***	0.011 [0.001]***	0.013 [0.002]***
$\beta_{\tau\tau}$	0.033 [0.003]***	0.033 [0.003]***	0.034 [0.003]***	0.036 [0.003]***	0.041 [0.003]***

Source: author's calculations.

TABLE [I-7B] –SENSITIVITY ANALYSIS ON $\alpha_{\tau y}$ (DETERMINISTIC TREND ASSUMPTION)

	$\alpha_{\tau y} = 0.5$	$\alpha_{\tau y} = 0.75$	$\alpha_{\tau y} = 1$	$\alpha_{\tau y} = 2$	$\alpha_{\tau y} = 3$
α_{gy}	-0.089 [0.041]**	-0.096 [0.041]**	-0.104 [0.042]**	-0.134 [0.474]***	-0.168 [0.057]***
$\alpha_{g\tau}$	-0.032 [0.140]**	-0.300 [0.140]**	-0.277 [0.141]**	-0.187 [0.151]	-0.097 [0.170]
$\alpha_{\tau y}$	-0.5	-0.75	-1	-2	-3
$\alpha_{y\tau}$	-0.002 [0.033]	0.017 [0.034]	0.037 [0.035]	0.121 [0.043]***	0.212 [0.060]***
β_{gg}	0.025 [0.002]***	0.025 [0.002]***	0.025 [0.002]***	0.025 [0.002]***	0.025 [0.002]***
β_{yy}	0.008 [0.001]***	0.008 [0.001]***	0.008 [0.001]***	0.009 [0.001]***	0.011 [0.001]***
$\beta_{\tau\tau}$	0.029 [0.002]***	0.030 [0.002]***	0.030 [0.002]***	0.032 [0.003]***	0.036 [0.003]***

Source: author's calculations.

The careful analysis of Figure [I-9] leads to the conclusion that the alternative models in some instances will generate similar impulse-response functions, that is, implying that the identification procedure is not important in that particular case. This is especially true for the spending responses, and the stochastic-trend tax receipt response. In these cases, there is almost complete superimposition of the IRFs. For the trend-stationary tax response, there is a weak correlation between tax responses and output-tax elasticity [$\alpha_{\tau y}$] – with higher values of $\alpha_{\tau y}$ being associated with stronger negative rebounds at the first quarter (after a positive response at impact). About the output responses, on the other hand, it could be said that the sensitivity test on $\alpha_{\tau y}$ makes all the difference: low output-tax elasticity models [$\alpha_{\tau y} \leq 1$] present output responses to tax innovations that are not statistically significant and do have a similar behavior to the recursive response. High output-tax elasticity models [$\alpha_{\tau y} \geq 2$] have statistical significant negative responses. Given the fact that the recursive response is totally insignificant and very much closer to zero, let's compare the cumulative output response of the various models with the structural model when $\alpha_{\tau y} = 2$ [*benchmark model*]: Under stochastic-trend hypothesis, the impact impulse-response from the $\alpha_{\tau y} = 1$ model [*Ilzetzki model*] is one-fifth of the impact benchmark's IRF. The same proportion is found when comparing the cumulative IRFs of the two models for the whole sixteen-period horizon. The $\alpha_{\tau y} = 3$ model [*extreme model*], on the other hand, has both impact and cumulated IRFs that are 1,4 times higher than the *benchmark* responses. Under trend-stationarity, the results are roughly the same with *Ilzetzki* responses being at most one-fifth and *extreme* responses being 1,5-1,6 times the *benchmark* responses.

Figure [I-10] shows the results of applying the sensitivity test to output shocks. The alternative identifications did not altered the pattern, already revealed in Section 4.1 by the recursive model, that output shocks do not cause meaningful responses of the spending variable. In all alternative cases, the instantaneous impact of output on spending is restricted to zero on the structural matrices; thus, alternative models don't alter this first zero correlation; consequently, spending responses are statistically insignificant in both DGP assumptions. The dynamics are very different for the tax responses: since the sensitivity analysis assumes different values for the instantaneous impact of output on taxes, the models present very different IRF values, especially at the time of the shock. Under both DGP assumptions, the recursive and low output-tax elasticity models the maximum responses occur at the first quarter after the shock. This changes for the high elasticity models: for the *benchmark* and *extreme* models, the maximum responses occur at impact at much higher value: in both data generating process assumptions, the *benchmark* impact response is more than two times the *Ilzetzki* value (and five times the recursive response), but still being 30% smaller than the *extreme* model. However, as the figure shows, the high-elasticity models have responses with more rapid decrease. For example, at their maximum value (at the first quarter), the low-elasticity responses are greater than those from the high-elasticity models. This reflects in terms of cumulated IRFs ratios. *Ilzetzki*'s cumulative response stabilizes between 80% and 90% the *benchmark*'s (depending on the DGP). Also, the *extreme* response decreasing more rapidly than the *benchmark*'s itself and converges to the latter. In conclusion, the importance of the aforementioned results is, in terms of policy, the fact that the high-elasticity models are more capable being strongly counter-cyclical already at the short-run. Finally, the last row of Figure [I-10] gives the output responses to it's own shock under the various identification models. In contradiction to tax responses, there's an inverse relation between the magnitudes of the output responses and the value of the output-tax elasticity. The reason might be aforementioned positive relation between the output-tax [$\alpha_{\tau y}$] and tax-output [$\alpha_{y\tau}$] elasticities: since high $\alpha_{\tau y}$ implies high $\alpha_{y\tau}$, then a business shock when $\alpha_{\tau y}$ implies a great increase in tax receipts which has a depressing effect on output itself. Notwithstanding, the effect of $\alpha_{\tau y}$ on the business cycle is small: *Ilzetzki*'s response is 10% higher than the *benchmark*'s, which, in turn, is also 10% higher than the *extreme* response. These values are valid for both the impact responses and the cumulative IRFs ratios.

CHAPTER 6: EXPANDED MODEL

6.1 EXPANDING THE BASIC MODEL

The structural VAR application of the previous chapter was composed of three endogenous variables: *i)* government spending; *ii)* output and *iii)* tax receipts. There, it was found that tax receipts innovations had strong negative effects on output when identification is achieved fixing a high output-tax elasticity. This finding was in line with Blanchard and Perotti (2002) [U.S. economy] and Peres (2006) [Brazil], among others. The international literature generally finds positive output effect coming from spending shocks (even though this is not consensual) – the same, however, cannot be said about the Brazilian literature. Spending shocks, according to the results from the last chapter, caused positive responses on output but not significantly so: Brazilian spending policy would be ineffective as a counter-cyclical tool. This result contradicts Peres (2006) and Blanchard and Perotti (2002) and Ilzetzki (2011); Cavalcanti and Silva (2010) found more similar results. Mendonça *et al.* (2009), on the other hand, found *negative* output effects.

This chapter will investigate the effectiveness(less) of Brazilian spending policy further. In order to achieve the objective, it's necessary to detail which categories in the overall expenditures are driving the results found previously and, hopefully, found categories that can do influence economic activity at the short-run. In Chapter 4, three spending categories were analyzed: *a)* benefits; *b)* wages and *c)* defrayals. Figure [I-2] and the discussion in the data analysis highlighted some pattern that affect and will affect the share of the spending categories in the future: benefits spending grew at a higher rate than overall expenditures; while wage spending grew less, decreasing its share along the way. Defrayal spending had abrupt reduction due to a few adjustments but ended the period [2015:1] with a similar share found at the beginning of the period of analysis [1997:1]. In light of such distinct behaviors, and also because of the distinct nature of each kind of spending, it's possible that each category is influencing economic activity in a particular way. From the basic autoregressive model of the last chapter, an expanded version will be proposed next. The expanded model keeps two variables – tax receipts and output – but substitute three spending categories for the overall spending; this procedure will probably bring new insights and help to uncover the root causes of the overall spending ineffectiveness or, at least point which types of spending is driving the results from the basic (three-variable) model and which ones could serve as counter-cyclical tools. Given specific tendencies previously found for each spending categories, the impulse-response results of each category shock will can lead to interesting discussion about the consequences of the categories tendencies in terms of their effects on Brazilian output.

The inclusion of the spending categories will expand last chapter's basic model from a three-variable to a five-variable autoregressive model. The methodology will remain the same: the problem of lack of identification of the true DGP applies also to the variables of the larger model, still necessitating estimations under the two DGP assumptions. Notwithstanding, the tax receipts and output variables remains the same of the basic model. Since the impact of the structural identification and the sensitivity analysis is largely restricted to the effects of tax on output and vice-versa, i.e., with marginal effects on the effects of the spending variable, the application of the same exercise of testing alternative identifications values for the output-tax elasticity would show a pattern similar to the one found in Section 5.3.[40] This permits focusing on the analysis of the spending effects, that is, the effects of expenditures categories on the system. Off course, impulse-responses of tax receipts shocks will also be presented, but only of the structural *benchmark* model $[\alpha_{\tau y} = 2]$.

6.2 IDENTIFICATION

In Chapter 3 (methodology), it was seem that an exactly identified structural model would require 3 restrictions on the structural matrix. This requirement came from the fact that the variance-covariance matrix of a reduced-form model of order 3 does have 6 distinctive variables – the variance-covariance matrix $[\Sigma_u]$ is symmetric. Since the standard deviations of the structural errors should be estimated endogenously – the main diagonal of matrix B in the system $Au = B\varepsilon$ –, only three values were left to identify the parameters of the structural

[40] Complete set of IRFs available upon request.

matrix (see Eq. [9] and discussion nearby). The substitution of three spending categories for overall spending augments the order of the VAR model to five. The new variance-covariance matrix now has $n^2 = 25$ elements with $n^2 - [(n^2 - n)/2] = 15$ distinct values. On contrast, by normalizing on parameter in each row, there are still 20 free parameters on the structural matrix:

$$A_S u = B\varepsilon$$

$$\begin{bmatrix} 1 & -\alpha_{bw}^S & -\alpha_{bd}^S & -\alpha_{by}^S & -\alpha_{b\tau}^S \\ -\alpha_{wb}^S & 1 & -\alpha_{wd}^S & -\alpha_{wy}^S & -\alpha_{w\tau}^S \\ -\alpha_{db}^S & -\alpha_{dw}^S & 1 & -\alpha_{dy}^S & -\alpha_{d\tau}^S \\ -\alpha_{yb}^S & -\alpha_{yw}^S & -\alpha_{yd}^S & 1 & -\alpha_{y\tau}^S \\ -\alpha_{\tau b}^S & -\alpha_{\tau w}^S & -\alpha_{\tau d}^S & -\alpha_{\tau y}^S & 1 \end{bmatrix} \begin{bmatrix} u^b \\ u^w \\ u^d \\ u^y \\ u^\tau \end{bmatrix} = B \begin{bmatrix} \varepsilon^b \\ \varepsilon^w \\ \varepsilon^d \\ \varepsilon^y \\ \varepsilon^\tau \end{bmatrix} \qquad [11]$$

Where the sub indices b, w and d represent *benefits*, *wage* and *defrayal* spending categories, respectively; and y and τ represent output and tax receipts (as before). The α parameters give the contemporaneous impacts of the variables on each other and u and ε are the reduced-form and structural errors, respectively.

Of the 15 distinct elements of the new Σ_u matrix, 5 will be used to identify the main diagonal of the B matrix and the other 10 will serve to identify the parameters in A_S. 10 parameters still need to be restricted somehow. First, the structural matrix of the larger model in Eq. [11] still has the same parameter, the output-tax elasticity, to be identified, as the basic model. Thus, the restriction used before is still valid here. Second, the identification of the basic model also relies of the assumption that the government sector does not, or cannot, change its expenditures in order to counteract economic shocks (such as unexpected tax receipts or output realizations) within the same quarter. What does this last assumption implies whereas the new model has three spending categories instead of the overall expenditure? Naturally, by definition, if the public sector cannot significantly alter its overall spending in response to the economic environment, it cannot alter any of its categories either. Therefore, the basic model's assumptions leads to the following restrictions: $\alpha_{by}^S = \alpha_{wy}^S = \alpha_{dy}^S = \alpha_{b\tau}^S = \alpha_{w\tau}^S = \alpha_{d\tau}^S = 0$ and $\alpha_{\tau y}^S = 2$. So, without any extra assumptions, there are already 7 restrictions on the model.

The extended model requires 3 more restrictions (to achieve identification) that cannot be derived from previous assumptions, which already established that all three spending categories do not suffer contemporaneous impacts from output or taxes. However, a recursive structure to the block of spending categories – from which three extra restrictions can be derived – may be theoretically sound. First, it's necessary to realize that benefits spending category is completely exogenous: what drives benefits disbursements are the demographic dynamics given the current legislation (retirement and social security). The federal government does not have discretionary power to alter social security expenditures in a timely fashion; the process to do so can only be achieve by legislation reforms carried out through the legislative body. It's possible that the executive branch can marginally alter these expenditures – say, being more rigorous in giving benefits approvals and combating corruption in the social security system – but these minor actions are hardly correlated to business cycles and taxes within a single quarter – and even less so to unexpected realizations of wage and defrayals expenditures. This reasoning leads to two more restrictions: $\alpha_{bw}^{S} = \alpha_{bd}^{S} = 0$ (yet, unexpected benefits' realizations may affect government's budget constraint, forcing counteractions inside the spending policy as to alter wage and defrayals expenditures within a quarter. The parameters α_{wb}^{S} and α_{db}^{S} should be left free). The last restriction comes from the evidence about the behavior of defrayal expenditures found in the data analysis of Chapter 4. The defrayals series dynamics were much like a residual variable, especially during certain periods, like the fiscal adjustments of 1998 and 2003. Taking this into account, one could argue that defrayals, at least the short run, could behave as the residual component of the spending policy: once the benefits and wage expenditures were known, the last spending category could adjust accordingly – whether by increasing or decreasing. This reasoning would imply, then, that benefits and wage expenditures can have contemporaneous effects on defrayals (α_{db}^{S} and α_{dw}^{S} should be free parameters in the model) while the last does not influence the first two variables, i.e., $\alpha_{wd}^{S} = 0$ ($\alpha_{bd}^{S} = 0$ was already established by the previous assumption). The remaining parameters of the structural matrix can be set free to be estimated within the exactly identified structural model, which takes the form as in Eq. [12]. Note that the instantaneous impact of taxes on output is a free parameter instead of zero – guaranteed by the restriction $\alpha_{\tau y}^{S} = 2$ already used in the previous chapter.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ -\alpha_{wb}^S & 1 & 0 & 0 & 0 \\ -\alpha_{db}^S & -\alpha_{dw}^S & 1 & 0 & 0 \\ -\alpha_{yb}^S & -\alpha_{yw}^S & -\alpha_{yd}^S & 1 & -\alpha_{y\tau}^S \\ -\alpha_{\tau b}^S & -\alpha_{\tau w}^S & -\alpha_{\tau d}^S & -\alpha_{\tau y}^S = -2 & 1 \end{bmatrix} \begin{bmatrix} u^b \\ u^w \\ u^d \\ u^y \\ u^\tau \end{bmatrix} = B \begin{bmatrix} \varepsilon^b \\ \varepsilon^w \\ \varepsilon^d \\ \varepsilon^y \\ \varepsilon^\tau \end{bmatrix} \qquad [12]$$

The reduced-form estimation (see Eq. [1]) of the previous chapter was carried out with two lags on the autoregressive vector, i.e., a total of $[(n)^2p + 2k] = [(3)^2.2 + 2(3)] = 24$ coefficients.[41] As much as would be interesting to make comparison between basic and extended models using the same number of lags on the autoregressive components, this possibility is impaired by the fact that, in the case of the extended model, the number of estimated coefficients would rise to $[(5)^2.2 + 2(5)] = 60$ coefficients. This would be problematic in when the sample counts only 73 observations from 1997:1 to 2015:1, and even less so for estimating the actual models with lags. The problem with degrees of freedom imposes the use of a more parsimonious model: using just one lag, the extended model can be estimated with $[(5)^2.1 + 2(5)] = 35$ coefficients, saving 25 degrees of freedom and permitting a much more accurate estimation. Fortunately, the expanded model with just one lag on the autoregressive component already produces white-noise forecast errors; several information criteria also choose one lag as optimal.[42]

As previously stated, the problem of DGP assumption remains prevalent in the extended model. Two estimations, therefore, i.e., one for each DGP assumption, will be carried out. The impulse-response functions of the extended model are presented on Figures [I-11] to [I-15]. Figure [I-16] exhibits selected IRFs comparisons between the basic and extended models. The presentation's structure remains the same: panel *(a)* showing IRFs under the stochastic-trend assumption and panel *(b)* showing trend-stationary impulse-response functions; in the extended model, however, there are five shocks to be investigated, one for each endogenous variable. Analyzing the results, it is possible to conclude that the expansion was worthwhile – breaking the spending variable into three categories produced new findings that would not be identifiable otherwise. Additionally, some findings from the basic model were confirmed.

[41] The formula used here to count the number of coefficients on the VAR model is slightly different from the traditional one $[(n)^2p + p]$ (n being the number of endogenous variables and p the number of lags), because the actual reduced-form model includes two dummy variables: the first is a dummy which assumes value 1 for $t > 2000{:}\,2$ (Brazilian fiscal responsibility act was enacted in the second quarter of 2000); the second is a pulse (dummy) variable with value 1 at the last quarter of 2009 – when the international crisis hits the Brazilian economy.

[42] Statistics available upon request.

Table [I-8] presents the log-likelihood estimation of the structural matrix (Eq. [11]), similar to Tables [I-6] and [I-7]: the output-tax elasticity is fixed [$\alpha_{\tau y} = 2$]; the table shows only the estimated free parameters (with the exception of $\alpha_{\tau y}$). Naturally, the model is estimated in both DGP assumptions. Most of the parameter elasticities of the estimated structural matrices are statistically insignificant; but the few that are significant are strongly so (at the 1 percent level): the wage-defrayal [α_{dw}], the defrayal-output [α_{yd}] and the tax-output [$\alpha_{y\tau}$] elasticities. The first and second significant elasticities are new, i.e., absent from the basic model. The first, α_{dw}, gives evidence that an unexpected shock on wage spending generates a significant response of defrayals in the same direction. It's noticeable that this elasticity is substantially stronger under trend-stationarity (about 28%). The second, α_{yd}, gives the instant elasticity of output to defrayals shock. The positive (significant) value gives the only case in which a spending category influences output. Finally, the last elasticity, $\alpha_{y\tau}$, already appeared in the basic model and was analyzed in detail in Section 5.2 of the last chapter: the high output-elasticity of taxes is associated with a high value of tax-output elasticity. The comparison between estimates from Tables [I-6] and [I-8] shows that the value for $\alpha_{y\tau}$ is robust – with the estimate under stochastic-trend in the extended model being just slightly lower than the basic model's estimates; and the opposite being true under trend-stationarity.

The structural identification keeps driving the strong negative output response after tax shocks. The second row of Figure [I-16] makes the comparison between the basic and extended models responses (grey and black lines, respectively). Under the stochastic-trend hypothesis, the impulse-responses of both models have practically the same behavior and also the same order of magnitude (the expanded model somewhat weaker: 7 percent and 13 percent at the end of the sixteen-period horizon). On the contrary, the trend-stationary response has stronger responses, both at impact (21 percent) and also when comparing accumulated IRFs (80 percent) – displaying a more persistent behavior.

The third row of Figure [I-16] gives output responses to it's own shock, i.e., a measure of persistence of the business cycle in the Brazilian economy. Its shares with the second row the feature that the extended model behaves more persistently under trend-stationarity, at the same time that the responses under the stochastic-trend hypothesis are practically identical. In the latter case, the impact response of the five-variable model is only 4 percent weaker; converging to be almost of the same magnitude to basic model's cumulated response after sixteen-periods (99 percent). Under the trend-stationarity, the impact response of both models are also similar (only 4 percent higher for the extended version), with a 30 percent difference (also in favor of the extended model) between the cumulated IRFs at the 16th period.

TABLE [I-8] –STRUCTURAL MATRIX ESTIMATION (EXTENDED MODEL; STRUCTURAL IDENTIFICATION)

	STOCHASTIC TREND	DETERMINISTIC TREND
α_{wb}	-0.135 [0.130]	-0.043 [0.131]
α_{db}	0.329 [0.290]	0.006 [0.275]
α_{yb}	-0.051 [0.043]	-0.007 [0.049]
α_{tb}	-0.216 [0.168]	-0.128 [0.152]
α_{dw}	-0.872 [0.262]***	-1.120 [0.247]***
α_{yw}	-0.022 [0.041]	0.014 [0.049]
$\alpha_{\tau w}$	-0.169 [0.161]	0.011 [0.155]
α_{yd}	-0.055 [0.018]***	-0.065 [0.022]***
$\alpha_{\tau d}$	-0.051 [0.068]	-0.075 [0.065]
$\alpha_{\tau y}$	-2	-2
$\alpha_{y\tau}$	0.110 [0.036]***	0.153 [0.049]***
β_{bb}	0.029 [0.002]***	0.025 [0.002]***
β_{ww}	0.032 [0.003]***	0.028 [0.002]***
β_{dd}	0.070 [0.006]***	0.058 [0.005]***
β_{yy}	0.010 [0.001]***	0.010 [0.001]***
$\beta_{\tau\tau}$	0.040 [0.003]***	0.032 [0.003]***

Source: author's calculation.

The most important new evidence comes from the comparison between the spending categories impacts and the overall spending impact on economic activity. These are shown in the first row of Figure [I-16]: dashed-black lines show the basic model's output responses to the overall spending shock; solid light-grey lines give the responses from benefits' shocks; solid dark-grey lines, from wage shocks and solid black lines give the output responses from defrayals shocks. These responses are the same presented in the last rows of Figures [I-6], [I-11], [I-12] and [I-13], respectively. As before, overall spending shock generates positive output responses, but these are not statistically significant. On the contrary, the defrayal spending generates positive and significant responses. The significance output responses after a defrayal shock occur in both DGP assumptions, and are maintained in the first quarter after the initial shock. Also, both panels of Figure [I-16] show that the responses from basic spending and defrayal spending are very similar in magnitude (3 percent under stochastic-trend and 6 percent under trend-stationarity). The decreasing of the IRFs are much more rapid of the basic model thus creating a much weaker cumulated impact. At the 16th period horizon, the cumulated output responses a defrayal shock is 49 percent [stochastic-trend model] and 385 percent higher [trend-stationarity] than the response from the basic overall spending shock. The striking result from the latter has much to do with the fact that the overall spending shock response has a negative and persistent rebound from the 3rd to the 11th period; whereas in the panel *(a)* there are only minor and intermittent negative rebounds too close to zero that does not makes much difference of the accumulated results.

Contrary to defrayals shocks, benefits and wage shocks give rise to insignificant output responses. Under the stochastic hypothesis, these insignificant responses attain a positive peak at impact and converge to zero rapidly. Under the trend-stationarity, the response from the benefits' shock is initially negative but rapidly turns to positive, resulting in a positive cumulated impulse-response function; the response from the wage spending shock has a peak at the impact and a negative rebound from the 2nd to the 15th quarter after the shock. The cumulated impulse-response is negative in this case. Especially in the trend-stationarity case, after the firsts quarters, is dominated by the behavior give by the wage shock. To give a complete idea of the difference between the consequences of defrayals in relation to the other spending categories, compare the impulse-response in terms of the former: in the stochastic model, the response of output to a defrayal shock is 7,4 and 9,4 times higher than the responses from a benefits' and a wage spending shock. Under trend-stationarity, these ratios are 2,4 and -6,2. The cumulative IRF ratio between defrayals and wage spending cannot be interpreted so straightforwardly because the cumulative response in the latter case is negative (not significantly so). This negative value is the reason why the ratio of cumulative IRF responses between defrayals and overall spending shock is 4,8 – between the two previous numbers.

Finally, there is yet another feature of the defrayal spending that distinguishes it from the other two spending categories: defrayals' is the only type of expenditure in which its shocks generates statistically significant tax responses (see Figure [I-13]), at least on impact. This characteristic might be an evidence of a possible outcome from Brazilian fiscal rules, which may be more biding in the case of this kind of spending than for the other two. Fiscal legislation in Brazil requires that new expenditures have to be approved by the legislative if, only if, there is fiscal capacity, that is, available receipts to finance the new spending. However, it's reasonable to suggest that this rule would not apply instantly to such categories as benefits' and wage spending: these are continuous expenditures that, benefits' more than wages, behave independently from the government short-run policy. As argued before, this is also behind the nature of defrayals spending being a kind of residual spending variable. For the same reason, exogenous shocks on defrayals would need to be more contemporaneously financed – since the other two categories cannot be accommodated – generating more tax receipt at the present time.

CHAPTER 7: FINAL REMARKS

This study tried to perform a thorough analysis of the effects of Brazilian fiscal policy – government spending and taxes – on economic activity. As a by-product, the investigation also managed to produce some results regarding the role the fiscal policy during the business cycle, i.e., the effects of output on government tax receipts and spending. To analyze the aforementioned economic effects, it was constructed structural impulse-response functions from vector autoregressive models. To derive impulse-response functions from reduced-form errors two central assumptions were used: first, that the authorities could not respond rapidly enough to innovations from the economic environment (output and tax receipts dynamics); and second, that the output-tax elasticity had a specific value – not derived within the models but from other studies from the Brazilian literature – imposed to the structural VAR models. The reduced-form model used quarterly data from the first quarter of 1997 to the first quarter of 2015. Primarily, basic model was estimated, with three variables: *i)* government spending, *ii)* government tax receipts and *iii)* output (GDP). The first two variables were measures of fiscal policy and the last one the measure of economic activity. Next, an extended model was presented, substituting 3 spending categories (benefits', wage and defrayals') for the overall spending variable. Thus, the extended model was composed of five endogenous variables.

Both the basic and the extended models had relevant information indicating that the behavior of the estimated impulse-response functions were dependent on the assumptions about the data generating process of the vector of endogenous variables one is working with. Both the 3-variable and the 5-variable models were estimated under two assumptions: first, under the assumption that all series were unit-root [stochastic-trend model; stochastic model]; and second, under the assumption that all series were trend-stationary [trend-stationarity model; deterministic model]. Each assumption required a particular type of variable transformation procedure to turn a explosive model into a stationary model (both unit-root and trend-stationary are not stationary). A second source of IRFs disparities in terms of shapes and values come from the identification strategy. Two strategies were used: first, the recursive method, that imposed an order of causation between the variables; and second, the structural method *per se*, which restricted the entries of the structural matrix according to assumptions about the capacity of the government to respond to the economic environment as well as external information about a specific parameter, the output-tax elasticity. The external information permitted to set another parameter from the structural matrix free, giving more flexibility in relation to the previous recursive model and with substantial implication, especially in terms of tax effects. Finally, also regarding tax effects, trying values on the output-tax elasticity (sensitivity analysis) showed that the IRFs behaviors were highly dependent on this parameter. The sensitivity analysis showed that that the magnitude of the output response to tax shock were positively correlated with the output-tax elasticity because in the identification procedure, the output-tax elasticity were correlated with the tax-output elasticity – this last measuring the contemporaneous impact of taxes on output. The evidence shows that the effect of taxes on economic activity would be negligible only if the output-tax elasticity were also too small – as the implied value of the recursive model.

The evidence from the basic model suggests that economic activity did not respond substantially to spending shocks but respond strongly to tax shock, if in fact the output-tax elasticity is high. Thus, tax policy seems more suitable to be used as a counter-cyclical macroeconomic policy – which can be important during recessions. The expansion of the basic model was important to identify which type of spending was driving the ineffective result from the basic model. The extended model's IRFs have shown that benefits' and wage shocks were statistically insignificant, whereas the defrayals' shocks had significant effect on output. If spending should be used as a counter-cyclical tool, the government should focus on the defrayal category. However, it's important to have in mind that defrayals' shocks are related with tax increases, which can be having an indirect depressing effect. Finally, both the basic and the extended models agree on a controversial issue. The model generated impulse-response functions with a counter-cyclical feature; a result not yet found in the Brazilian empirical literature. The pattern is the results of a highly positive and significant tax response and an insignificant spending response. This result does not depend of the identification strategy, even though the positive response is much stronger under the latter case. Again, this finding contradicts previous applications of autoregressive models with Brazilian data; the international literature has as more or less certain that developing countries do a pro-cyclical or, at best, neutral fiscal policy.

At this point it's not possible to assert with certainty if the evidence presented in this study is robust, i.e., if the results are sustained, with a more complete set of fiscal variables. The first problem is related to the fact that the study uses fiscal variables that are in fact, just a subset of the complete government sector. As argued in the data analysis, this study uses the federal government spending and tax receipts as proxies of the consolidated government (federal, state and local) – since the latter is not available in the required frequency. A potential problem with this strategy would be if state and local fiscal series have behaved in a distinct manner vis-à-vis the federal series. A complete spending series could, either enhance the conclusion that overall spending is ineffective as a counter-cyclical tool or, on contrary, generate a significant response for this shock. There is no *a priori* expectation regarding this problem. The evidence suggests, however, that the federal government comprises much more than 50 percent of the consolidated government.

Secondly, taking aside the first problem, the definition of government spending used in the empirical applications excluded a few expenditures that might be instantaneously correlated with economic activity. In doing so, the present study tried to approximate Brazilian fiscal series to the common definitions used in the international literature – with excludes the so-called *automatic stabilizers* from the workable series of government spending. This is crucial for the identification procedure since permits restricting the instantaneous impact of spending on output to zero and, therefore, permits exact identification of the structural matrix. The presence of substantial residual components correlated with economic activity would invalidate the structural identification. Notwithstanding, if the spending series still has residual automatic stabilizers, the consequence would be a *negative* contemporaneous impact of output on spending (i.e., negative output innovations *increase* spending). If output-spending elasticity could be restricted, then, to a negative value, most likely the structural spending response to output shocks would be more negative – at least at the impact. This, in turn, would imply a *stronger counter-cyclical fiscal policy*. If, on contrary, one argues that Brazilian political institutions are so pro-spending that might have created mechanism that counterbalances the remaining automatic stabilizers to the point of government spending being highly responsive to the business cycle (in the same direction), then the previous conclusions would change. This, however, would necessitate very strong output-spending elasticity to counteract the positive output-tax elasticity.

This study concludes attesting that more research is need for this topic. Efforts should be made in generating complete series of the consolidated public sector (both spending and receipts). This would practically reopen a new series of researches on the effects of Brazilian fiscal policy. New estimations, especially regarding the true value of the output-elasticity of taxes would be need.

PART TWO

IDENTIFYING BRAZILIAN FISCAL EPISODES: AN INTERVENTION ANALYSIS APPROACH

CHAPTER 8: INTERVENTION ANALYSIS

The objective of part I was to measure the impact of Brazilian fiscal policy on economic activity. Using a structural vector autoregressive methodology, specific values were imposed on the contemporaneous correlations (structural matrix) to identify the structural shocks, especially of the fiscal variables.[43] The identification was based on two main assumptions: the first premise states that the government lacks the capacity to respond instantly – within the quarter – to the economic environment; the second premise is, in fact, the restriction of a specific value to be imposed on the output-tax elasticity parameter of the structural matrix.

Part II will adopt an alternative approach – one that should be considered as complementary to the previous structural analysis. This alternative approach relies on the *intervention analysis* methodology: the method simply will specify one or more periods that could be described as being exogenous fiscal events, i.e., whether a spending or a receipt variation, that can be known in advance (before the model estimation). If there are in fact such episodes, these can be isolated with deterministic dummy variables on the reduced-form model itself – i.e., expanding from Eq. [1] – that is, impulse-response functions can be derived from such dummies in the same fashion as impulse-responses derived from the forecasted errors of a VAR model, by the assumption that each dummy will represent an exogenous event. Since the dummy variables will not be correlated with forecasted errors, the IRFs derived from them can be interpreted as being structural.

This approach, in order to allow comparisons with the previous structural analysis, will present a very similar reduced-form model than that of part I; for the same time period (1997:1-2015:1) and the same set of endogenous variables: the three variable model (spending, tax receipts and output) and the five variable model (i.e., benefits', wage, defrayal, output and tax receipts). Therefore, besides the addition of the fiscal episodes as dummies, the alternative approach follows Part I on estimating the basic and the extended model for the same time period.

[43] See Chapter 3 for a detailed description of the dataset.

The advantage of simplicity of using the intervention analysis and rely solely on the reduced-form model is counterbalanced by the necessity of specifying a rigorous methodology to select the points in time that could represent truly exogenous events (i.e., *fiscal episodes*, in the following). Obviously, the specific points should be related to fiscal policy change. The credibility of the dummy impulse-responses (as the conclusion derived from them) will be as good as the credibility of the dummies being representing actual exogenous fiscal shocks.

A methodology will be set forth to choose the exogenous fiscal shocks. In sum, the fiscal episodes will be those quarters with the greatest quarter-to-quarter variations of government spending and tax receipts. The meaning of a *fiscal episode*, then, will be: ac action of government represented by a percentage change of its expenditures or tax receipts that is large and, at the same time, is not a response to the dynamics of the model itself, specifically a response to the output. Only when those instances can be detected in the data, the reduced-form impulse-response functions can be interpreted properly.

Probably the first application of intervention analysis to fiscal shocks analysis comes from the *narrative approach method* of Ramey and Shapiro (1998). They realized that the U.S. government spending data had some unusual changes that could not be attributed to a natural dynamic of the data itself. According to Blanchard and Perotti (2002), there is some specific realizations on U.S. quarterly data, swings of [government] expenditures and tax receipts, that "*are simply too large to be treated as realizations from the same underlying stochastic process and must be treated separately*"[44]. One should control for the atypical episodes before applying a time series model. Ramey and Shapiro (1998) offered a clever way to control for those singular events: they noted that large increases of government spending were associated with military *build-ups* – the Korean War, the Vietnam War and the Carter-Reagan build-up. The argument is that the beginning of the build-ups should be considered as exogenous events. Clearly, these events are not the result of a fiscal policy to counterbalance a slowing down of economic activity – but are responses to external political events rather independent of the state of the U.S. economy. Take, for example, the Korean War: Ramey and Shapiro set the beginning of the build-up to be 1950:3. The U.S. military spending represented 6,5 percent of the American GDP before the War.[45] In 1952-53, the military spending represented 15 percent of the U.S. output.[46] This change is simply too large to be

[44] BLANCHARD, P., PEROTTI, R. 2002, p. 1330.
[45] North Korean army launched a surprise invasion of South Korea on June 30, 1950.
[46] See Figure 5 of Ramey and Shapiro (1998).

treated as coming from the same stochastic process. Similarly, Blanchard and Perotti (2002) treated the 33 percent fall of U.S. government receipts in 1975:2 (tax rebate) as another true exogenous fiscal policy shock not related with the contemporaneous state of U.S. economy.[47]

Actually, Ramey and Shapiro (1998) applied their narrative approach to a wide range of macroeconomic data, but in a univariate time series analysis context. Latter on Edelberg, Eichenbaum and Fisher (1999), Burnside, Eichenbaum and Fisher (2004) and Eichenbaum and Fisher (2005) used Ramey-Shapiro military dates in a multivariate time series analysis. Eq. [13] is a generalization of the narrative approach to a multivariate analysis:

$$x_t = \alpha + \lambda(L)x_t + \delta D_t + u_t$$
$$\lambda(L) = \sum_{i=1}^{p} \lambda_i L^i \qquad [13]$$

$$D_t = \begin{cases} 1, When\ t = 1950{:}3, 1965{:}1\ or\ 1980{:}1\ (military\ build\ ups) \\ 0, Otherwise \end{cases}$$

Where x is the vector of endogenous variables; α is the vector of deterministic terms. Generally, it represents the constant term, but may be expanded to contain structural (known) breaks, time trends, etc.; the polynomial $\lambda(L)$ is a lag function where each λ_i is a $[k \times k]$ matrix; u_t is a white-noise column vector $[E(u_t) = 0; E(u_t u'_t) = \Sigma_u; E(u_t u'_s) = 0\ \forall\ s \neq t]$ and Σ_u is assumed to be a positive semidefinite, symmetric and non-singular; D_t is a dummy variable that represents exogenous events – that when applied to the U.S. case could represent the military build-ups.

Note that Eq. [13] has a structure almost identical to the reduced-form model in Eq. [1] except by the inclusion of a dummy variable, D_t. In Eq. [13] there is no macroeconomic time series – whether inside the x vector or as an exogenous variable – to represent exogenous fiscal events; rather, the system identifies fiscal events via the dummy, which assumes the values of 1 at specific points of time. In Ramey and Shapiro (1998) the dummy assumed the value of 1 at the beginning of each of the three military build-ups: $D_t = 1$ for 1950:3, 1965:1 and 1980:1, that is, the beginning of the increase in military spending due to

[47] See Figures I and II of Blanchard and Perotti (2002).

the Korean War, the Vietnam War and the Reagan build-up, respectively.[48] Thus, D_t representing these military spending shocks in the stylized model of Eq. [13] generates the following impulse-response functions, according to the infinite series $[\delta/(I-\lambda(L))] = \phi_1 + \phi_2 + \cdots + \phi_n$, where:

$$\frac{\partial x_{t+i}}{\partial D_t} = \phi_i \qquad [14]$$

Again, the specification of D_t according to Eq. [13], that is, all the events are of represented in the same dummy implies that the impulse-responses functions of Eq. [14] are, in fact, measuring a mean of median impact of all events. In other words, the specification above assumes that all spending increases have the same impact on the system. It was the work of Burnside, Eichenbaum and Fisher (2004) that extended Ramey and Shapiro (1998) approach to a vector autoregressive model, in a way to allow for differentiation between the military shocks. Burnside *et al.* achieve this by differentiating the magnitude of the military shock in the dummy variable: the Korean build-up took the value of 1 – since this was the event with stronger increase in share of military spending on GDP –; the other two military escalations had a value of between 0 and 1, reflecting the relative magnitude of the military spending increase in relation to the Korean event. As it is the case in all dummies, the variable assumed the value of zero at all the other periods outside the military shocks. This requires only a slightly change in the model of Eq. [13],

$$D_t = \begin{cases} \psi_1 = 1\ at\ 1950{:}\,3\ (Korean\ war) \\ \psi_2\ at\ 1965{:}\,1\ (Vietnam\ war) \\ \psi_3\ at\ 1980{:}\,1\ (Reagan\ build\ up) \\ 0,\ otherwise \end{cases}$$

[48] Actually, Ramey and Shapiro (1998) and others inserted the dummy variable in a polynomial lag structure (4 lags). This is possible by the large size of U.S. quarterly macroeconomic data. The lag structure on the dummy variable complicates a bit the calculation of the impulse-response coefficients ϕ in Eq. [14] (which is formed by the reduced-form coefficients λ and δ). Nevertheless, all military build-ups will still have the same impact (i.e., the same IRFs) on the system, thus permitting express the impulse-response functions by the series of Eq. [14].

However, the behaviors of the impulse responses (the shape of the IRFs) are the same for all military shock: the only change occurred in the magnitude of the initial shocks (the value of D_t); thus, this difference in the magnitude of the shock is incorporated by the impulse-responses, that now have different values for each event, $\psi_j[\delta/(I-\lambda(L))] = \psi_j\phi_1 + \psi_j\phi_2 + \cdots + \psi_j\phi_n$. Thus,

$$\frac{\partial x_{t+i}}{\partial D_t} = \psi_j\phi_i \qquad [15]$$

Where $\psi_1 = 1$ and $0 < \psi_j < 1$ if $j = 2,3$.

Again, the fact that the military events marked by the Ramey-Shapiro dates were deemed as exogenous permitted to treat them by the classic intervention analysis approach: this permits deriving from the dummies impulse-response functions directly from reduced-form models without the necessity to identify the structural underlying errors as was the case in Part I. If one could find, in the Brazilian quarterly data, analogous fiscal events, not in terms of large military spending increases, but in terms of being large enough to be treated as exogenous – i.e., events on the spending or tax receipts series that are particularly different to be interpreted as being of the same stochastic process –, then one could extended the intervention analysis to study the effects of fiscal shocks in Brazil.

The present study applies the aforementioned methodology to the Brazilian case, identifying the periods in the recent recorded history of quarterly economic data that could have had an analogous role in comparison to the Ramey-Shapiro dates (again, not in magnitude and type of the spending, but in the sense that they might represent exogenous events of *policy change*). In the following, Chapter 9, a specific criterion to identify the potential fiscal events will be presented. There, the greatest shocks in both fiscal variables will be deemed as exogenous shocks. High changes in both spending and tax receipts were located and high *negative* and *positive* changes in the spending variable were located. Contrary to the military build-ups of Ramey and Shapiro (1998) and Burnside *et al.* (2004), the variety of fiscal shocks in the Brazilian cannot be aggregated into one dummy variable. Each shock will appear with its own dummy, generating a specific impulse-response function. Chapter 10 (methodology) will clarify these changes.

The results show that specific cases of fiscal episodes generate very distinct behavior from those found in the previous chapter. The tax receipts increase did not had a significant depressing effect on the economy; the same being true about the fiscal episode of spending increase. The criterion to locate fiscal events found two instances of spending contractions with very different consequences on output: the first, which had a higher proportion of defrayals spending on the overall contraction, had significant keynesian-like negative effect on economic activity; where as the second contraction had not significant effects. Even though the average response due to the structural fiscal shocks seems to have the traditional behavior – positive effect to spending shocks and negative effects to tax shocks, as found in Part I – the evidence suggests that the economy can respond very distinctively to specific shocks.

CHAPTER 9: IDENTIFYING FISCAL EPISODES

The following analysis uses the same vector of macroeconomic variables that was used in Part I's structural model. As well as in the previous application, the analysis will also estimate two models, the basic model and an extended version. The vector of endogenous variables in the basic model is composed of: Brazilian output, federal government spending and federal government receipts. The extended model substitutes the spending categories (benefits', wage and defrayals') for the overall government spending; the tax receipt and output remains the same. The sample is limited for the period from 1997:1 to 2015:1. A detailed analysis of the data is conducted in Chapter 4 (data analysis).[49] There, a battery of unit-root test were carried out to uncover the true nature of each series time-trend, i.e., whether the variables were trend-stationary or unit-root processes. The treatments necessary to turn these two non-stationary processes into stationary ones – before any estimation – were already discussed. The evidence regarding the nature of the time-trends are, for all cases, ambiguous.[50] In light of the evidence, the same strategy of estimating two models is adopted: first, it is assumed that the all variables are unit-root processes, in which case the necessary transformation is simply to first-difference all variables; second, it is assumed that all variables are trend-stationary, in which case all variables must be de-trended before entering the autoregressive estimation. This strategy permits a collateral investigation regarding the behavior of the impulse-response under different data generating processes (DGP) assumptions. In the following, the analysis will focus on the problem of identifying the so-called *fiscal episodes*, since the description of the macroeconomic variables and the investigation about their true DGP can be reported to the discussion in Chapter 4.

The greatest challenge of using the intervention analysis on Brazilian macroeconomic data is to find instances that represent truly exogenous shocks. First, the fact is that only a reduced sample size is available already implies a smaller probability that any large-scale

[49] Federal government expenditures and receipts are constructed from the monthly data made available by the National Treasury Secretary (STN) of the Ministry of Finance. The Brazilian Institute of Geography and Statistics (IBGE) makes GDP series available. IBGE also makes available the implicit deflator used to calculate real variables. See Section [3] of the previous chapter for detail. Unless otherwise stated, through all text, the terms *government spending* or *government receipts* always refers to central government's variables.

[50] See Tables [I-2], [I-3] and [I-4].

fiscal event may have happened in the first place. The sample size counts only 73 observations in total (and the usable number of observations is reduced further depending on the number of lags of the autoregressive model). Secondly, it is also a fact that the Brazilian economy did not experience anything comparable with large-scale fiscal events such as the U.S. military *build-ups* – as described by Ramey and Shapiro (1998) – that were characterized by sudden increase in military spending, which turned out to be very persistent. Nonetheless, few economies may have experienced events of such magnitude, and even fewer would have recorded data in terms of quarterly macroeconomic data. At the same time, one still might be able to identify some dissimilar fiscal variation, that is, some large changes in Brazilian government spending and receipts that seems considerably atypical to the point to be treated as exogenous events.

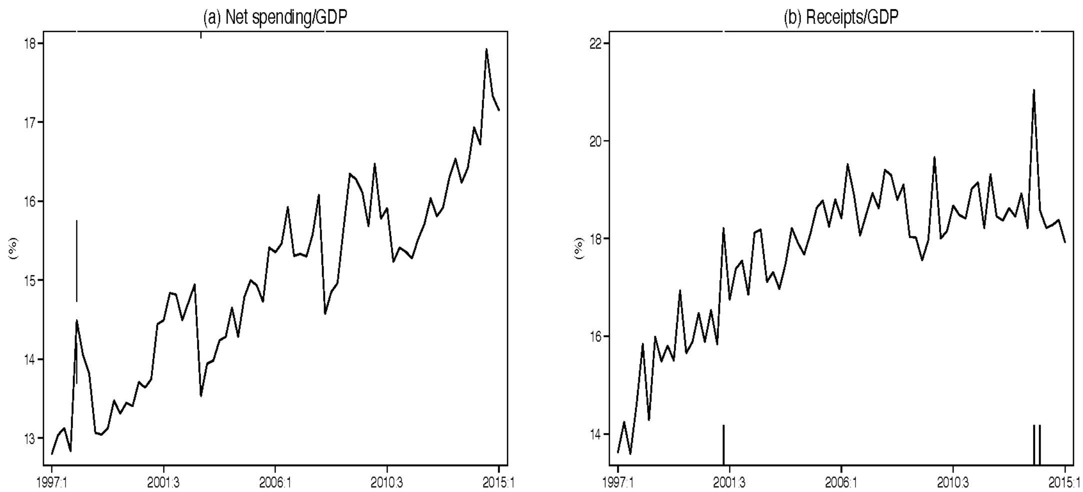

FIGURE [II-1] – GOVERNMENT SPENDING AND RECEIPTS (SHARE OF GDP).
Source: IBGE/STN.

Figure [II-1] reproduces the federal government's spending-GDP [panel *(a)*] and receipts-GDP [panel *(b)*] ratios. One can quickly identify some points of large increases and decreases of these ratios. Take the period 2003:1, for example. Section [4.1] described the evolution of the GDP and the fiscal variables, referring to the instability of the last quarters of 2002 and the first quarters of 2003 as being marked by slowing economic growth and accelerating inflation – the consequence of the then imminent change in political power at the federal government. Unexpectedly, though, the newly elected federal government set forth a contractionary fiscal policy that reduced the spending-GDP ratio by more than one percentage point (p.p.) already in the first quarter of 2003. Latter on, it will be argued that the magnitude of this movement qualifies it as highly atypical, thus permitting the period to be treated as containing an exogenous and unforeseen policy change. A more technical criterion of choosing fiscal episodes in fact selects 2003:1 as a spending-reduction fiscal episode.

But how should one define an atypical fiscal shock, that is, a fiscal episode? For the purposes of the present study, a fiscal episode is that period of time, a given quarter, in which one of the two fiscal variables (government spending or government receipts) has an unlikely large variation (positive or negative). This unlikely variation is then interpreted as a disruption of the normal dynamics of the data generating process of the respective variable. Following the U.S. literature of narrative approach, the event is controlled by a dummy variable in the reduced-form autoregressive model. The underlying assumptions is that the investigation of the dynamic response of the dummy variable itself, one is analyzing the effect of the fiscal episode. It should be added that the criterion to select such events should be rigorous enough as to drawn only a few instances: by definition, an dissimilar change in the data should not occur regularly.

Figure [II-2] exhibits the quarterly percentage point change of the spending-GDP and receipts-GDP ratios.[51] The standard deviations of these series are 0,48 p.p. and 0,90 p.p., respectively. A rigorous criterion for selection of just a few episodes is to impose the necessity that, to be chosen as fiscal episode, the quarterly change must exceed 2,5 times its own standard deviation. With this decision rule, only a handful of events can be describe as fiscal episodes. The decision rule implies that only when quarterly spending-GDP ratio change exceeds 1,21 p.p. then there's a spending fiscal episode and when the receipts-GDP ratio change exceeds 2,25 p.p. there is a tax receipt fiscal episode. This percentage point change can be positive or negative. A contractionary fiscal policy is characterized by positive changes in receipts-GDP ratio or negative changes in spending-GDP ratio and an expansionary fiscal policy is related the opposite, that is, a negative change in the receipts-GDP ratio and a positive change in the spending-GDP ratio. The horizontal dotted lines in panels *(a)* and *(b)* of Figure [II-2] are the positive and negative 2,5 standard deviation limits of the spending-GDP and the receipts-GDP changes, respectively.

[51] That is, each panel of Figure [2] is the graphical representation of $z_t(=\frac{x_t}{y_t}-\frac{x_{t-1}}{y_{t-1}})$, where x may be spending [panel *(a)*] or receipts [panel *(b)*] and y is the gross product (GDP); z is the percentage point change.

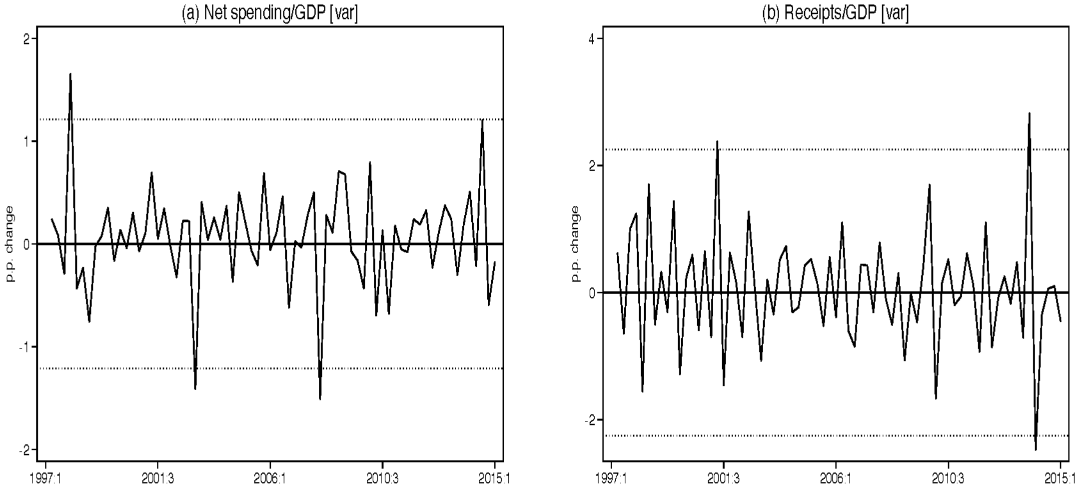

FIGURE [II-2] – PERCENTAGE CHANGE OF SPENDING-GDP AND RECEIPT-GDP RATIOS
Source: IBGE/STN

The inspection of Figure [II-2] shows that there are three cases of spending-GDP ratio changes and three cases of receipts-GDP ratio changes that exceed the respective 2,5 standard deviation limit, totalizing six potential fiscal episodes. For the spending variable, there is a case of policy expansion [1998:1] and two cases of policy contractions [2003:1; 2008:1]; on the other hand, for the receipts variable, there is one case of policy expansion [2014:1] and two cases of contractions [2001:2; 2013:4]. Back to Figure [I-1], it is now clear that the vertical grey lines are plotted exactly at the six potential fiscal episodes. It may be worthwhile to point out some characteristics of these potential fiscal episodes. First, it is important to note that there is not a single case in which both spending *and* tax receipt fiscal episodes occur *simultaneously*. This is a mere coincidence, not a *ex ante* restriction, but is an important coincidence: the absence of simultaneous episodes does more than making the analysis easier – it makes the investigation possible; it makes the possible the measurement of each and everyone of the six potential cases. If, otherwise, there was a case of simultaneous fiscal episodes, then it would be impossible to separate the output dynamics due to the spending episode from the dynamics due to tax episode. A second characteristic of the potential fiscal episodes is that they are reasonable, for the most part, that is, usually located at points that one should expect that the *de facto* fiscal episodes would be: local peaks and valleys of the spending-GDP and receipts-GDP ratios. Thirdly, however, there are exceptions to the overall good characteristics of the episodes. The last two– and subsequent – percent point changes of the receipts-GDP ratio are problematic – and could be misleading to use the p.p. change as the sole criterion to choose the fiscal events. The problem is that the two receipts changes are close together, one is subsequent to the other, and with opposite signs. the 2013:4 large increase is the receipts ratio is followed by a large decrease in that same variable at the following quarter, with about the same order of magnitude and opposite sign – effectively offsetting the previous movement. This can disqualify these two variations as true fiscal episodes: one might conjecture the reason for this odd pattern. It seems plausible to suggest that those two large variations are *not* the result of conscientious policy (given their offsetting nature). The data also does not support the claim that they are automatic response from economic activity shocks. It looks more probable to be a case of delay or advance on the collection of tax receipts that distorted the series at that particular time. In this case, the distortion would be aggravated if, in 2013:4, the seasonality adjustment algorithm,[52] did not discounted the normal path of seasonality because of the unusual large variation, exacerbating the problem (i.e., the unusual variation was interpreted as being totally genuine, needing no discount).[53] Whatever the reason, the pattern of the last two potential episodes invalidates then as real fiscal shocks. From now on, the focus will be entirely on the remaining four.

In fact, four fiscal episodes instances in a small sample such as the available here, with quarterly data for the period 1997:1-2015:1, is more than enough. Each extra shock would bring more impulse-responses to analyze and jeopardize the robustness of the autoregressive estimation by reduction of the degrees of freedom – already a pervasive problem in empirical applications with Brazilian macroeconomic data. The number of fiscal episodes could be reduced even further, by a more rigorous criterion: for example, it is possible to fix the limit of percentage point change to three standard deviations – instead of two and a half. That more rigorous criterion would require dropping the 2003:1 fiscal contraction; increasing the limit even further would get to the point where would be just one and then zero fiscal episodes to be analyzed. The 2,5 standard deviation limits is maintained as the benchmark, since dropping the 2003:1 episode does not have consequences to the dynamics of the other three shocks. Additionally, losing the 2003:1 fiscal episode would be costly in the sense that this episode is very important in terms of its consequences to economic activity, and its unique in terms of the spending categories distribution in the contraction – see Table [II-1].[54]

Table [II-1] presents the behavior of government receipts, spending and spending categories at the time of selected four fiscal episodes. Panel I exhibits the quarterly percentage

[52] The three time series (GDP, tax receipts and government spending) were seasonally adjustment by the ARIMA-X12 method.
[53] The receipts-GDP ratio without seasonal adjustment has a positive seasonality in the last quarter of the year, in relation to the first quarter.
[54] These results are available upon request.

point change of each variable ratio (always in relation to GDP) while Panel II gives the share of each spending category on the total percentage point change of the spending-GDP ratio in panel I. For example, the 0,2 p.p. increase in the benefits-GDP ratio in the first fiscal episode [1998:1] represents approximately 13% of the overall 1,7 p.p. change in the spending-GDP ratio. The others statistics of Panel II are constructed analogously. The table shows that the increase of 2,4 p.p. in the receipt-GDP ratio that occurred in 2001:2 stands as the greatest fiscal expansion, followed by a 1,7 p.p. increase in the spending-GDP ratio in 1998:1. The two spending contractions [2003:1; 2008:1] had 1,4 p.p. and 1,5 p.p. change variations. The second panel leaves no doubt that the spending shock are dominated by the defrayal spending – which always comprises more than 50% of the overall spending p.p. change. It is notorious that the 74% proportion of defrayals on the overall p.p. change reduction of the spending-GDP ratio in 2003:1. On the other hand, benefits' is never expected to comprise a large proportion of any change in spending-GDP ratio; this category is by far the most rigid, with its own determinants (demographics, social security laws) and cannot be the object of a large change in fiscal policy in the short-run. The overall tendency of this category is to increase in the near future, augmenting its share on the overall spending-GDP ratio. This was the case even in the spending contraction of 2003:1, when the benefits-GDP ratio had an increase. However, the 2008:1 fiscal contraction, by the same account, had an inexplicable decrease in this same ratio.

TABLE [II-1] – VARIATION OF SPENDING AND RECEIPTS ON THE FISCAL EPISODES

Variables	1998:1	2001:2	2003:1	2008:1
	I - *Percentage change (p.p.)*			
Receipts	-	2.38	-	-
Total spending	1.7	-	-1.4	-1.5
Benefits spending	0.2	-	0.1	-0.6
Wage Spending	0.6	-	-0.4	-0.1
Defrayal spending	0.9	-	-1.0	-0.9
	II - *Share of total spending (%)*			
Benefits spending	12.7	-	-5.71	38.3
Wage Spending	33.6	-	31.4	5.22
Defrayal spending	53.7	-	74.3	56.5

Source: STN/IBGE

Note: Panel I shows the percentage point change of spending (and its categories) and receipts; Panel II gives the share of each category on the total p.p. change of the total spending reported on the first panel.

CHAPTER 10: METHODOLOGY

Even though this study is based on Ramey and Shapiro (1998) idea of intervention analysis to identify exogenous fiscal events, some minor changes must be made in their strategy of using dummy variables. The present circumstance is one with a variety of fiscal episodes, not of the same kind, and even not all of the same sign: there is a complete heterogeneity between the four events – in terms of type, magnitude, direction and composition: there are two types of episodes (spending and tax receipts episodes); these episodes differ in magnitude in relation to each other; of the subset of spending episodes, two are contractionary and one is expansionary; and finally, the composition of the spending categories varies in each of these spending cases. At first sight, one could adopt on dummy variable for the tax receipt episode; one dummy for the expansionary spending episode and one more dummy, following Burnside *et al.* (2004), to the two contractionary spending episodes. The reduced-form model would look like:

$$x_t = \alpha + \lambda(L)x_t + \delta_1 D_{1t} + \delta_2 D_{2t} + \delta_3 D_{3t} + u_t$$
$$\lambda(L) = \sum_{i=1}^{p} \lambda_i L^i \qquad [16]$$

Where,

$$D_{1t} = \begin{cases} 1 \; if \; t = 1998{:}1 \\ 0, otherwise \end{cases}$$

$$D_{2t} = \begin{cases} 1 \; if \; t = 2001{:}2 \\ 0 \; otherwise \end{cases}$$

$$D_{3t} = \begin{cases} 0{,}9 \; if \; t = 2003{:}1 \\ 1 \; if \; t = 2008{:}1 \\ 0, otherwise \end{cases}$$

The advantage of using Eq. [16] model to measure the impact of the fiscal effects is parsimony. However, this model still does not resolve the issue point out earlier, regarding the distribution of the spending categories in each of the fiscal contractions. Eq. [16] models still forces both spending contractions to generate the same pattern of impulse-response, the only difference being the proportionality factor of 0,9 at the 2003:1 episode in relation to the 2008:1 episode: according to Table [II-2], the 2008:1 fiscal adjustment was slightly stronger – i.e., had a stronger decrease in overall spending –, implying a greater effect on output. However, the conclusions of Part I would suggest that the quality of the fiscal adjustment would matter: the fact that 2003:1 adjustment has a different distribution between benefits', wage and defrayal spending in relation to the 2008:1 adjustment might be more important than the magnitude of the adjustment itself, especially since the two adjustment are not so different in terms of the percentage change of the overall spending. For instance, the structural impulse-responses from the extended model (Chapter 6) suggest that a shock on defrayals had a positive and significant effect on output, several times the magnitudes of the benefits and wage shocks; in fact, these last two shocks did not have any significant effect at all on economic activity (the initial output response to a benefits' shock could be even negative).

By Table [I-1] the first fiscal adjustment [2003:1] is 10 percent smaller than the second [2008:1]. Additionally, the first adjustment is disproportionally more intense in defrayals (about 74% of the total change in the spending-GDP ratio at that quarter); the second adjustment, by contrast, had an important component of the spending-GDP ratio reduction attributed to the benefits-GDP ratio reduction, completely absent in the first adjustment. It seems highly plausible to interpret these events as potentially having distinct effects on economic activity. One could measure, then, a much more richer landscape by separating the two fiscal contractions at the cost of just one extra dummy variable in the reduced-form model:

$$X_t = \boldsymbol{\alpha} + A(L)X_{t-1} + \delta_1 D_{1t} + \delta_2 D_{2t} + \delta_3 D_{3t} + \delta_4 D_{3t} + u_t \qquad [17]$$

$$\lambda(L) = \sum_{i=1}^{p} \lambda_i L^i$$

$$D_{1t} = \begin{cases} 1\ if\ t = 1998:1 \\ 0, otherwise \end{cases}$$

$$D_{2t} = \begin{cases} 1\ if\ t = 2001:2 \\ 0\ otherwise \end{cases}$$

$$D_{3t} = \begin{cases} 1\ if\ t = 2003:1 \\ 0\ otherwise \end{cases}$$

$$D_{4t} = \begin{cases} 1\ if\ t = 2008:1 \\ 0\ otherwise \end{cases}$$

Next chapter presents the main results from the estimated model of Eq. [17]. The reduced-form model above differs from the VAR model of Part I by the four dummy variables, representing four distinct fiscal episodes, by a dummy variable that takes the value of 1 when $t \geq 2000:2$ and another that takes the value of 1 when $t = 2008:4$. These two dummies were incorporated implicitly in the parameter $\boldsymbol{\alpha}$ of the equation. The first dummy represents a possible change of the constant due to the 2000s *Brazilian Fiscal Responsibility Act*, which put limits in government debt and set rules for a more sound fiscal policy. The second dummy takes the value of 1 at the impact of the 2008's international crisis. The model had a better adjustment with the inclusion of such shocks. The following chapters will show and discuss the results – in terms of impulse-response functions – of Eq. [17] model. It will become clear that that separating the shocks into different dummies was worthwhile, since each shock generating output responses that was distinctive in each case.

CHAPTER 11: RESULTS

11.1 FISCAL EFFECTS

This section outlines the main results from the empirical model of Eq. [17]. The exposition follows the same pattern already set forth in part I: The IRFs graphs are exhibited in figures containing two panels: panel *(a)* brings the impulse-response functions under the stochastic-trend assumption and panel *(b)* will show the impulse-responses under trend-stationarity. Differently from Part I's figures, each row gives a impulse-response functions to one fiscal episode. The first row will show IRFs from the 1998:1 spending episode; the second row gives the impulse-responses from the 2001:2 tax receipts shock; the third row exhibits responses from the 2003:1 spending episode and the fourth row the impulse-response from the 2008:1 spending episode. All the impulse-response functions are collected in the Appendix II, divided into two groups. The first group is comprised by Figures [II-3]-[II-5]. In this figures relevant comparison are made between different impulse-responses: sometimes comparisons between responses from the same underlying model (e.g., tax receipts vs. spending responses from the basic model); sometimes comparisons between responses from different models (e.g., the overall spending responses from the basic models against the spending categories responses from the extended model). The second comprises Figures [II-6]-[II-13], which exhibits the complete set of impulse-responses functions, individually presented, with confidence intervals. The basic model is presented in Figures [II-6] to [II-8] while the extended model comprises Figures [II-9] to [II-13]. The second group can be used to confirm certain statements in the text regarding the statistical significance of certain responses. Much of the investigation, however, can be carried out by inspection of the figures from the first group, where the relevant comparisons are easily made.

Take Figure [II-3]. It gives government spending responses against the tax receipt responses using the basic model. It is reassuring to find that, in all cases, the *a priori* expectations are confirmed by the data: The first fiscal episode [1998:1] marks a significant spending increase; the second [2001:2], is marked by a significant tax receipt increase; the third [2003:1] and fourth [2008:1] episodes are marked by a stark and significant decreasing in the overall spending of the government sector. At the same time that the fiscal variable associated with each fiscal episode[55] is statistically significant, the other fiscal variable[56] is always not significant: take the government spending variable, associated with the 1998:1 episode. The shock generated a positive significant response of that variable and, simultaneously, an insignificant response of tax receipts. The other three episodes generated analogous responses. This dynamics reaffirms the argument that each fiscal episode is characterized by one type of fiscal policy change.

The estimation of an extended model allows comparisons between response behaviors of the spending categories – between the categories themselves and between them and the overall spending response of the basic model. This is done in Figure [II-4]. A complete analysis should combine information from Figure [II-3] and [II-4] to form a precise description of what is happening in each of the four fiscal episodes. The figures give enough evidence that in every episode, defrayal spending is the most sensible category, being several times stronger than the overall spending, especially in the two spending contractions episodes. Even though spending does not respond significantly to the episode of tax increases, there's a tendency of positive spending response, giving the relaxation of the government budget; defrayals', also in this case, is prominent within the spending categories. For the two last fiscal episodes, the defrayals' spending, apart from having the same direction of the overall spending shock, is statistically significant.

These patterns, about defrayals' responses – as well as for the other categories – are summarized in Table [II-2]. The table gives cumulated impulse-responses ratios, of each spending category in relation to the overall spending. Panel I shows the result for the stochastic-trend assumption while Panel II gives these ratios under trend-stationarity. The IRF ratio approach of Table [II-2] casts doubts about the preliminary conclusion derived from the summary statistics: according to Table [II-1] there were a more pronounced share of defrayals' on the fiscal contractions of 2003:1 in relation to the 2008:1 episode. However, even if defrayals had a more substantial role in the first contraction [2003:1], in terms of its share of the overall reduction of the spending-GDP ratio, regarding of the actual quantity of defrayals' reduction (its own response to the shock) the conclusion is not straightforward: under the stochastic assumption, the category response were more or less equivalent in the two fiscal episodes (about three times the overall spending response), while under trend-

[55] That is: spending [1998:1]; tax receipts [2001:2]; spending [2003:1]; spending [2008:1].
[56] That is: tax receipts [1998:1]; spending [2001:2]; tax receipts [2003:1]; tax receipts [2008:1].

stationarity, the 2008:1 episode had a far weaker defrayal response.[57] The DGP assumption also had some conflicting results relative to the wage responses. Under the deterministic assumption, both spending contractions had similar wage responses: a bit stronger than the overall spending response. However, the stochastic assumption generates a wage response that is very weak in 2008:1 episode. Finally, Table [II-2] confirms the expectation of weak benefits' responses to the fiscal events, particularly the spending contractions that in the case of the 2003:1 episode, converts in a positive cumulated response. Figure [II-4] and Table [II-2] show that the increase in the benefits'-GDP ratio was more the results of output dynamics than a great variation in the spending category itself. The rigidity of this variable is highly corroborated by the analysis of the actual impulse-response functions.

TABLE [II-2] – RATIOS OF CUMULATIVE IRFS OF THE SPENDING CATEGORIES.

	D1 [1998:1]			D2 [2001:2]			D3 [2003:1]			D4 [2008:1]		
	Panel I - Stochastic trend											
Lags	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*
0	2.4	0.9	0.1	1.4	1.2	0.5	2.8	1.0	0.0	3.3	0.4	0.4
1	2.2	1.0	0.3	1.6	1.3	0.6	3.4	1.4	-0.2	3.3	0.4	0.2
2	2.2	0.9	0.2	2.1	1.7	0.8	2.9	1.1	-0.2	3.0	0.4	0.2
3	2.2	0.9	0.3	1.6	1.3	0.7	3.0	1.2	-0.2	3.2	0.4	0.2
4	2.2	0.9	0.2	1.6	1.3	0.6	3.0	1.2	-0.2	3.1	0.4	0.2
5	2.2	0.9	0.3	1.9	1.5	0.8	3.0	1.2	-0.2	3.1	0.4	0.2
10	2.2	0.9	0.2	1.7	1.4	0.7	3.0	1.2	-0.2	3.1	0.4	0.2
16	2.2	0.9	0.2	1.7	1.4	0.7	3.0	1.2	-0.2	3.1	0.4	0.2
	Panel II - Deterministic trend											
Lags	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*	*Defray.*	*Wage*	*Benef.*
0	1.9	1.4	0.3	2.1	1.3	0.3	2.9	1.0	0.2	2.1	1.3	0.3
1	2.1	1.3	0.1	2.5	1.3	0.1	3.3	1.1	0.1	2.1	1.3	0.3
2	2.2	1.3	0.0	2.9	1.5	0.1	3.5	1.2	0.0	2.1	1.3	0.3
3	2.2	1.3	0.0	3.0	1.5	0.0	3.5	1.2	0.0	2.1	1.3	0.3
4	2.2	1.3	0.0	3.1	1.6	0.0	3.5	1.2	-0.1	2.1	1.3	0.3
5	2.3	1.3	0.0	3.1	1.6	0.0	3.4	1.2	-0.1	2.1	1.3	0.3
10	2.4	1.4	0.0	3.3	1.8	0.0	3.4	1.1	-0.2	2.1	1.3	0.3
16	2.4	1.4	0.0	3.4	1.8	0.0	3.4	1.1	-0.2	2.1	1.3	0.3

Source: author's calculation.
Note: The *Defray.* column gives the ratio between defrayal spending IRF (extended model) and the (overall) spending IRF (basic model). The *Wage* and *Benef.* columns give analogous results for these spending categories.

57 Each IRF calculation gives the response in relation to its own variable. The overall spending is the sum of all spending categories; therefore, its response, in absolute value, should always be greater than the responses of its own categories.

Figure [II-5] plots the output responses to the fiscal episodes. The evidence from the impulse-response analysis is very striking, if compared to the evidence of the first part of this study: in Part I, the structural VAR analysis established that a positive spending shock was potentially effective (i.e., had a positive output response), and in a significant manner if the shock were in the defrayal spending category. Also, the tax receipt shock had a highly negative impact on output, particularly if the output-tax elasticity was high. Nevertheless, the only fiscal episode to bring forth a significant output response was the 2003:1 spending contraction. The responses of the basic and the extended models under the stochastic assumption had the same sign, magnitude and shape and were significant only at the impact – a feature many times found in the structural analysis of Part I, i.e., the short-term impact of the fiscal shocks. Under trend-stationarity, the basic model produced a significant response that lasted until the first quarter while the extended model response continues to be significant on impact. The shape of the impulse-responses in the figure can mislead the reader into thinking the opposite – so it's important also to analyze the impulse-responses with confidence intervals.

Again, all others output responses had insignificant and expected responses – at least by the evidence found in Part I. First, the large 1998:1 spending increase is associated with a *negative* effect on economic activity, even though not statistically significant. This is troublesome also because the defrayals' are a large part of the expenditure increase and its response is positive and significant.[58] The tax increase in 2001:2 had the expected output response sign (i.e., the episode had a negative effect on the economy) even though not accurately estimated. The response was weak also when compared with the negative response from the 2003:1 adjustment: for example, the basic model estimation calculates that the decrease in output resulted from the latter fiscal adjustment, at impact, was between 1,8 [stochastic-trend] and 3 [trend-stationary] times stronger when compared with the responses from the tax increase in 2001:2. The number for the cumulated impulse-responses after the sixteen-period horizon are 2,3 and 2,2. The estimations of the extended model are similar. These responses are even more surprising given the fact that in terms of GDP ratios, the tax episode was almost 1 percentage point stronger than the spending episode (see Table [II-1]). On the other hand, the results of the first spending contraction are completely at odds with those from the last fiscal episode, which also found an insignificant output response: the spending contraction in 2008:1 – analogously to the spending increase episode of 1998:1 –

[58] Marginally significant in the case of the stochastic-trend assumption.

generated an output response with sing contrary to expected (the only exception being the extended model under stochastic-trend assumption).

11.2 Robustness

In their application of the narrative approach of Ramey and Shapiro (1998), to a VAR framework, Edelberg, Eichenbaum and Fisher (1999) calls attention to the problem of "date uncertainty". This issue concerns the possibility that the Ramey-Shapiro military dates may have been misspecified by some amount – in the sense that the true build-ups beginnings may have actually have happen a little earlier or a little latter. Edelberg *et al.* (1999), then, test the robustness of the results using Ramey-Shapiro dates by slightly moving their original location, and making comparison between the new and the original impulse-response functions. Each military episode is dislocated, each at the time, one, then two, then three quarters, both forward and backwards. Edelberg *et al.* argue that the new impulse-response functions in the neighborhood of the original dates should exhibit similar behavior, shape and magnitude, to the original results: given the magnitude of the build-ups, the events should dominate over minor errors of localization, at least in the neighborhood of the true events. Sizeable differences between the original and dislocated impulse-responses, however, would be evidence of non-robustness and, consequently, making the original results loose their economic significance.[59]

The argument above, though, is probably not valid outside applications with U.S datasets – and maybe a few other developed countries with large sample size of macroeconomic data. In Brazil, for instance, the expectations from the robustness test of "date uncertainty", as the one applied by Edelberg *et al.* (1999) to Ramey-Shapiro dates might be particularly contradictory in comparison to the original application. The small interval of quarterly macroeconomic data available precludes any analysis of important economic historical events of earlier decades. Even if a large sample of Brazilian quarterly data existed, the fact is that Brazil is still a relatively small economy with a minor role in world affairs,

[59] This robustness test confirmed the significance of the Ramey-Shapiro war dates as truly representing the beginning of the military build-ups.

which, almost sure, would preclude any recorded large-scale fiscal escalation (military or political) that might be deemed as important as the military escalations were for the U.S. economy.[60] The objective of the present study was to find more modest, but still exogenous, fiscal innovations that could be the result of *sudden policy change.* This could be attainable, and even more so than in the case of the fiscal policy of developed countries because of the fact that the fiscal policy of developing and poor countries are much more intermittent and, to a certain degree, not predictable; the four fiscal episodes described in Chapter 9 may well fit into this category of fiscal shock.

To understand why the fiscal episodes described above are feasible, and also why impulse-response functions that they generated are credible, it's important to take notice of some specific characteristics of the Brazilian fiscal shocks. Whether the result of structural identification (Part I) or intervention analysis (present case), the Brazilian fiscal innovations tend to generate short-lived responses (i.e., the output or even the fiscal responses do not maintain statistical significance for long periods, being so only at impact and, sometimes, at the first quarter after the initial shock). This fact is important, if combined with the argument set forth, for example, Ilzetzki, Mendoza and Végh (2013), which states the case that developing countries suffer from a systemic volatility in their fiscal policy (i.e., the policy changes quickly and unexpectedly) at the cost of a lack of credibility by the economic agents about future planning by the authorities. As an oblique consequence, anticipations of future fiscal policy are also impaired. According to Ilzetzki *et al.* (2013), even Central Banks from these developing countries cannot anticipate future fiscal innovations. This feature, if true also in the Brazilian case, makes the fiscal episodes found previously more credible, even though more modest in relation to the large military build-ups of Ramey and Shapiro (1998) and other for the U.S. economy.

The above features that might be attributed to the Brazilian fiscal policy, if make more credible the fiscal episodes outlined in Chapter 9, on the other hand, may complicate the robustness test of Edelberg *et al.* (1999). If the fiscal episodes [1998:1; 2001:2; 2003:1; 2008:1] are correctly specified, the impulse-responses from assumed shocks on the neighborhood would behave, theoretically very distinctively from the impulse-responses from the actual episodes. The reason for this is related with the fiscal policy features outlined earlier: the expectations regarding the impulse-response functions from fixing the fiscal episode one quarter earlier are distinct because volatility and non-anticipation ensure that the

[60] Brazil's last effective sizeable military operation took place in the middle of the twentieth century in sending the Brazilian Expeditionary Force (twenty-five thousand strong) to fight the Second World War in Italy.

fiscal policy of the earlier quarter is most likely not similar to the prevailing one, for one hand, and agents would not be responding in advance to an fiscal episode that still has not happened yet; fixing the episode one quarter latter generates distinct responses because the consequences of a fiscal episode rarely is propagated to the next quarter and, most likely, the quarter would be suffering the impact of another fiscal policy potentially different from the pretended fiscal episode. In sum, the expectations of the robustness test would be of *distinct* impulse-responses, the opposite of the original application. Nonetheless, the robustness test can be applied if correctly interpreted. Given the fiscal policy features that most likely describe Brazilian data, one can apply the test expecting the alternative dates to generate *distinctive* impulse-response functions for the fiscal variables: if the four fiscal episodes are in fact unique (exogenous), and the volatility, non-credibility and non-anticipation of the fiscal policy is prevalent, then the neighborhood dates should generate spending and tax receipts responses with every kind of sign and behaviors, hardly coinciding with the original responses of Figure [II-3].[61]

The results of the robustness tests are presented in Figure [II-6]. The figure shows the responses of tax receipts and overall spending (basic model) assuming alternative dates for the four fiscal episodes, in the neighborhood of the original dates. The short-lived feature of the fiscal impulse-response functions also implies that the test needs to be carried out within the one-quarter neighborhood of the original dates (i.e., dislocations of the original dates to one quarter earlier and one quarter latter). Each row gives the robustness check for one fiscal episode, and the robustness test is presented for the relevant fiscal variable of the shock: for example, the first row exhibits the alternative impulse-response functions of the spending variable, given the fact that the 1998:1 episode is a spending increase episode. Each graph shows three responses: the one for the original date (same as Figure [II-3]); the one assuming that the relevant episode occurred one quarter earlier; the last assuming that the relevant episode occurred one quarter latter. In the first row, the assumptions are that the episode occurred in 1997:4 and 1998:2.[62]

The conclusion of the robustness test is unambiguous. In the neighborhood within one quarter of the original dates, the episodes are unique: generally speaking, the impulse-responses derived from the specifications that assumed the fiscal episode to be located one-

[61] The original robustness check of Edelberg *et al.* (1999) focused on the impulse-responses of the other macroeconomic variables, such as output, not on the fiscal variables themselves.

[62] In testing for each fiscal episode, the other episodes remain with their original dates. For example, in the first row of Figure [II-6], when anticipating and delaying the first episode (to 1997:4 or 1998:2), the original dates of the other fiscal episodes remained unchanged – i.e., fixed at 2001:2, 2003:1 and 2008:1.

quarter earlier had opposite signs in relation to the original responses, while the impulse-responses from the specifications that assumed the fiscal episode to be located one quarter latter do not present a definitive pattern –at times being of the same sign, sometimes being of opposite sign in relation to the original impulse-response. More importantly, the alternative impulse-responses are almost entirely statistically insignificant – the only exception being the tax receipt response of the specification assuming the episode to occur one quarter in advance (see second row of Figure [II-6]). The confirmation of the *a priori* expectation of distinct fiscal impulse-responses is evidence that the fiscal episodes are unique and, thus, valid.

CHAPTER 12: DISCUSSION

How does the present study's results relate to results found by other studies, especially those using the vector autoregressive framework, applied to measure the effects of fiscal policy on Brazilian economic activity? To answer this question, it's important to understand how the present study differentiates itself from the traditional narrative approach, beyond the fact that the latter was the theoretical basis for the former. First, it's necessary to keep in mind that the present study is a kind of aggregation of four different "cases of study", i.e., presenting the effects for four different fiscal innovations on Brazilian output. The methodology is based on the works of Ramey and Shapiro (1998) and posterior expansions as in Edelberg *et al.* (1999), Burnside *et al.* (2004) and Eichenbaum and Fisher (2005) – especially the second paper, which uses the Ramey-Shapiro dates in a quasi-dummy variable to measure their impact of government spending on economic activity and other macroeconomic variables using the VAR approach. Working with a smaller sample size, the present study worked with a more parsimonious model of three endogenous variables, latter expanded to a five-variable autoregressive model.

All the authors cited above tried measured the economic impact of the fiscal policy using a dummy variable – i.e., intervention analysis – have, in fact, identified only episodes of spending increases, characterized by the military escalations. They found that the spending exogenous increase was responsible for increases in economic growth. Obviously, episodes of military build-ups, by definition, do not contemplate spending decreases – the reduction of military spending did not take place at the rapid pace as the spending increases and could be so easily identifiable. Conclusions from the military build-ups about exogenous reductions of government spending can be drawn only assuming a symmetric effect. Regarding tax receipts episodes the works using the military dates of Ramey-Shapiro have nothing to say. Blanchard and Perotti (2002), using the more standard approach of structural identification, used a dummy variable to isolate the effect of a temporary large tax decrease in the U.S. economy in 1975:2, mixing, therefore, the structural approach with the Ramey-Shapiro narrative approach. In this application, the dummy variable generated output responses very similar to the ones from the typical structural tax shock. Since the literature of structural VAR usually more often than not find positive output responses to spending shocks, it's possible to state also that the intervention analysis for the U.S. economy found spending and tax shocks effects that agree with the estimated effects of the spending and tax shocks of the structural identification approach [see Fatás and Mihov (2001); Caldara and Kamps (2008; 2012) and Ramey (2011)]; and even with the sign-restriction approach [Mountford and Uhlig (2009)]. One should not forget, however, the contradictory results of Perotti (2004).

The analysis of the Brazilian fiscal episodes is different from the U.S. military build-ups in many respects. The particularities with Brazilian dataset were outlined throughout the text. The methodology sketched above (see Figure [II-2]) found four fiscal episodes between 1997:1 and 2015:1 – a short interval in comparison with international standards. Probably this is the outcome of the pervasive fiscal volatility mentioned before. This volatility also permitted the identification criterion to find *both* spending and tax receipts episodes; and within the spending episodes, cases of positive and negative variation. This adds a variety to the Brazilian episodes that isn't present in the U.S. episodes. Chapter 9 showed that each spending contraction episode had a particular distribution in terms of benefits', wage and defrayals' in the total reduction of the spending-GDP ratio. This reasoning answers part of the question that opened this chapter: the methodology of identifying the four Brazilian fiscal episode is related to the narrative approach of Ramey and Shapiro (1998) and others, but differs from them in the sense that the Brazilian episodes are found to be much more complex than the all too similar U.S. military build-ups. It remains to relate the effects found in the present study with the Brazilian VAR literature.

As stated in Chapter 2, there are few relevant published works that deals with the issue of fiscal policy effects in Brazil using the vector autoregressive approach [Mendonça *et al.* (2009); Peres and Ellery Jr. (2009); Cavalcanti and Silva (2010); Ilzetzki (2011); Correia and Oliveira (2013)]. In general, the evidence suggests that spending increases do have positive effects on output – even though sometimes these effects are not deemed statistically significant; and negative effects on output from tax receipts increases. Brazilian literature is more or less in line with a important part of the international literature despite the fact that the results from the former are far more weak in terms of confidence. Mendonça *et al.* (2009), for example, found opposite results. The application of the sign-restriction methodology of Mountford and Uhlig (2009) to the U.S. data diminished the spending impact and augmented the tax effects, but did not reversed the general conclusions of the structural models, as the Brazilian application.

Of the four Brazilian fiscal episodes derived from criterion in Chapter 9, only the third [2003:1] caused the effect on output than one would expect, especially from the results of the structural model of Part I: In this case, the spending contraction had a statistically significant *negative* effect on the economy, in a typical, keynesian-like, case of recessive fiscal contraction. It was the only fiscal episode that engendered a response that would rule out Ricardian Equivalence. The hypothesis of Ricardian Equivalence cannot be rule out in the other three fiscal episodes – all of them turned out to be generate insignificant output responses, and the spending increase [1998:1] and the second spending contraction [2008:1] impulse-response had also sign contrary to the *a priori* expectation. The large confidence intervals preclude any categorical conclusions, but are the first indication that sometimes the fiscal impulses can be counterbalanced by the behavior of the economic agents to the point creating a situation resembling *expansionary fiscal contractions*. The tax receipt shock [2001:2] effect agrees with the *a priori* expectation (negative) but does not have significance. Overall, the evidence from these other shocks suggest that even though the literature finds, more often than not, keynesian fiscal effects, i.e., the *average* impulse-response functions of a spending or a tax receipts shocks has traditional keynesian behavior, specific cases of fiscal contraction or expansion can have outcomes very distinctive from a typical shock.

REFERENCES

ALESINA, A., PEROTTI, R. Fiscal adjustments in OECD countries: composition and macroeconomic effect. *IMF staff papers,* 44, p. 210-248, 1997.
AUERBACH, A.J., GORODNICHENKO, Y. Measuring the output responses to fiscal policy. *American Economic Journal: Macroeconomics*, Vol. 4, No. 2, 2012.
______. Fiscal multipliers in recession and expansion. In: ALESINA, A., GIAVAZZI, F. *Fiscal policy after the financial crisis,* University of Chicago Press, 2013, p. 63-98.
BAUM, C. Stata: the language of choice for time-series analysis? *The Stata Journal,* Vol. 5, No. 1, p. 46-63, 2005.
BAXTER, M., KING, R. Fiscal policy in general equilibrium. *The American Economic Review,* Vol. 83, No. 3, p. 315-343, 2003.
BLANCHARD, O., LEIGH, D. Growth forecasts errors and fiscal multipliers. *IMF working paper*, No. 13/1, 2013.
BLANCHARD, O., PEROTTI, R. An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *The Quarterly Journal of Economics*, v. 117, n. 4, p. 1329-1368, 2002.
BURNSIDE, C., EICHENBAUM, M., FISHER, J. Fiscal shocks and their consequences. *Journal of Economic Theory*, Vol. 115, No. 1, p. 89-117, 2004.
CALDARA, D., KAMPS, C. What are the effects of fiscal policy shocks? A VAR-based comparative analysis, *European Central Bank Working paper*, No. 877, 2008.
______. The Analytics of SVARs: a unified framework to measure fiscal multipliers, *Federal Reserve Financial and Economics Discussion series,* 2012.
CAVALCANTI, M.A.F.H., SILVA, N.L.C. Dívida pública, política fiscal e nível de atividade: uma abordagem VAR para o Brasil no período 1995-2008. *Economia Aplicada*, v. 14, nº. 4, p. 391-418.
CLEMENTE, J., MONTAÑÉS, A., REYES, M. Testing for unit root in variables with a double change in the mean. *Economic letters*, Vol. 59, p. 175-182, 1998.
CORREIA, F., OLIVEIRA, V. Reversão cíclica da política fiscal brasileira e a lei de responsabilidade fiscal, *Prêmio do Tesouro Nacional,* Inscrição: 67, 2013.
DOS SANTOS, C.H., COSTA, F.R. Uma metodologia de estimação da carga tributária bruta brasileira em bases trimestrais. *Economia Aplicada*, Vol. 12, No. 4, p. 581-606, 2008.
DOS SANTOS, C.H., PIRES, M.C.C. Reestimativas do investimento privado brasileiro I): qual a sensibilidade do investimento privado "referencia 1985" a aumentos na carga tributária? *Texto de discussão* IPEA, No. 1297, 2007.
EDELBERG, W., EICHENBAUM, M., FISHER, J. Understanding the effects of a shock to government purchases. *Review of Economic Dynamics,* Vol. 2, p. 166-206, 1999.
EICHENBAUM, M., FISHER, J. Fiscal policy in the aftermath of 9/11. *Journal of Money, Credit and Banking.* Vol. 37, No. 1, p. 1-22, 2005.
ELLIOT, G., ROTHENBERG, T.J., STOCK, J.H. Efficient tests for an auto-regressive unit root. *Econometrica*, Vol. 64, No. 4, p. 813-836, 1996.
ENDERS, W. *Applied econometric time series* (4th ed). New York: Wiley & Sons, 2015.
FATÁS, A., MIHOV, I. The effects of fiscal policy on consumption and employment: theory and evidence. *CEPR discussion paper*, No. 2760, 2001.
GALÍ, J., LÓPEZ-SALIDO, J.D., VALLÉS, J. Understanding the effects of government spending on consumption. *Journal of European Economic Association,* Vol. 5, No. 1, p. 227-270, 2007.
GIAMBIAGI, F. 18 anos de política fiscal no Brasil: 1991/2008. *Economia Aplicada*, Vol. 12, No. 4, p. 535-580, 2008.

GIAMBIAGI, F., ALÉM, A. *Finanças públicas: teoria e prática no Brasil.* 4ª ed. Rio de Janeiro: Elsevier, 2011.

GIAMBIAGI, F., TAFNER, P. *Demografia: a ameaça invisível.* Rio de Janeiro: Elsevier, 2010.

GIAVAZZI, F., PAGANO, M. Can severe fiscal contractions be expansionary? Tales of two small European countries. In: BLANCHARD, O., FISCHER, S. *NBER macroeconomics annual*, Vol. 5, Cambridge: MIT Press, 1990. p. 75-122.

ILZETZKI, E. Fiscal policy and debt dynamics in developing countries. *World Bank Policy Research Paper*, No. 5666, 2011.

ILZETZKI, E., MENDONÇA, E., VÉGH, C. How big (small?) are fiscal multipliers? *Journal of Monetary Economics*, No. 60, p. 239-254, 2013.

JÒRDA, O. Estimation and inference of Impulse Responses by local projections. *American Economic Review*, Vol. 95, No. 1, p. 161-182, 2005.

LINNEMANN, L., SCHABERT, A. Fiscal Policy in the new neoclassical synthesis. *Journal of Money, Credit and Banking*, Vol. 35, p. 911-929, 2003.

LUCAS, R. Econometric policy evaluation: a critique. *Carnegie-Rochester Conference of Public Policy*, 1, p. 19-46, 1976.

LÜTKEPOHL, H. *New introduction to multiple time series analysis.* Berlin, Germany: Springer, 2007.

MENDONÇA, M.J., MEDRANO, L.A., SACHSIDA, A. Avaliando efeitos da política fiscal no Brasil: resultados de um procedimento de identificação agnóstica. *Texto para discussão*, IPEA, No. 1377, 2009.

MOUNTFORD, A., UHLIG, H. What are the effects of fiscal policy shocks? *Journal of Applied Econometrics*, No. 24, p. 960-992, 2009.

NASCIMENTO, E.R., DEBUS, I. *Lei complementar No. 101/2000: entendendo a lei de responsabilidade fiscal.* 2.ed. Tesouro Nacional, 2003.

NELSON, C.R., PLOSSER, C.I. Trends and random walks in macroeconomics series: some evidence and implications. *Journal of Monetary Economics*, Vol. 10, p. 139-162, 1982.

OWYANG, M., RAMEY, V., RUBAIRY, S. Are government spending multipliers greater during period of slack? Evidence from twentieth-century century historical data. *American Economic Review: Papers & Proceedings*, Vol. 103, No. 3, p. 129-134, 2013.

PARKYN, O., VEHBI, T. The effects of fiscal policy in New Zealand: evidence from a VAR model with debt constraints. *CAMA working papers*, No., 4, 2013.

PEREIRA, M.C., ROCA-SANGALÉS, O. Long-term effects of fiscal policies in Portugal. *Journal of Economics Studies*, Vol. 38, No. 1, p. 114-127, 2011.

PEREIRA, M.C., WEMANS, L. Output effects of fiscal policy in Portugal: A structural VAR approach. *Banco de Portugal Economic Bulletin*, p. 7-34, 2013.

PERES, M.A.F. *Efeitos dinâmicos da política fiscal sobre a atividade econômica: um estudo para o caso brasileiro*. Dissertação (mestrado). Departamento de Economia, Universidade de Brasília, Brasília. 2006.

______. *Dinâmica dos choques fiscais no Brasil.* Tese (doutorado). Departamento de Economia, Universidade de Brasília, Brasília. 2012.

PERES, M.A.F., ELLERY JR., R. Efeitos dinâmicos dos choques fiscais do governo central no PIB do Brasil. *Pesquisa e Planejamento Econômico*, v. 39, No.2, 2009.

PEROTTI, R. Estimating the effects of fiscal policy in OECD countries. *IGIER Working papers*, No. 276, 2004.

PERRON, P. The great crash, oil price shock, and the unit root hypothesis. *Econometrica,* Vol. 57, p. 1361-1401, 1989.

RAMEY, V. Can government purchases stimulate the economy? *Journal of Economic Literature,* Vol. 49, No. 3, p. 673-685, 2011.

RAMEY, V., RUBAIRY, S. Government spending multipliers in good times and in bad: evidence from U.S. historical data. *NBER working papers*, No. 20719, 2014.

RAMEY, V., SHAPIRO, M. Costly capital reallocation and the effects of government spending, *Carnegie-Rochester Conference Series on Public Policy*, No. 48, p. 145-194, 1998.

SIMS, C. Macroeconomics and reality. *Econometrica*, Vol. 48, p. 1-48, 1980.

______. Are forecasting models usable for policy analysis? *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol. 10, No. 1, 1986.

ZIVOT, E., ANDREWS, D.W.K. Further evidence on the great crash, the oil price shocks and unit-root hypothesis. *Journal of Business and Economics Statistics.* Vol. 10, p. 251-270, 1992.

APPENDIX I

PART ONE'S IRFS

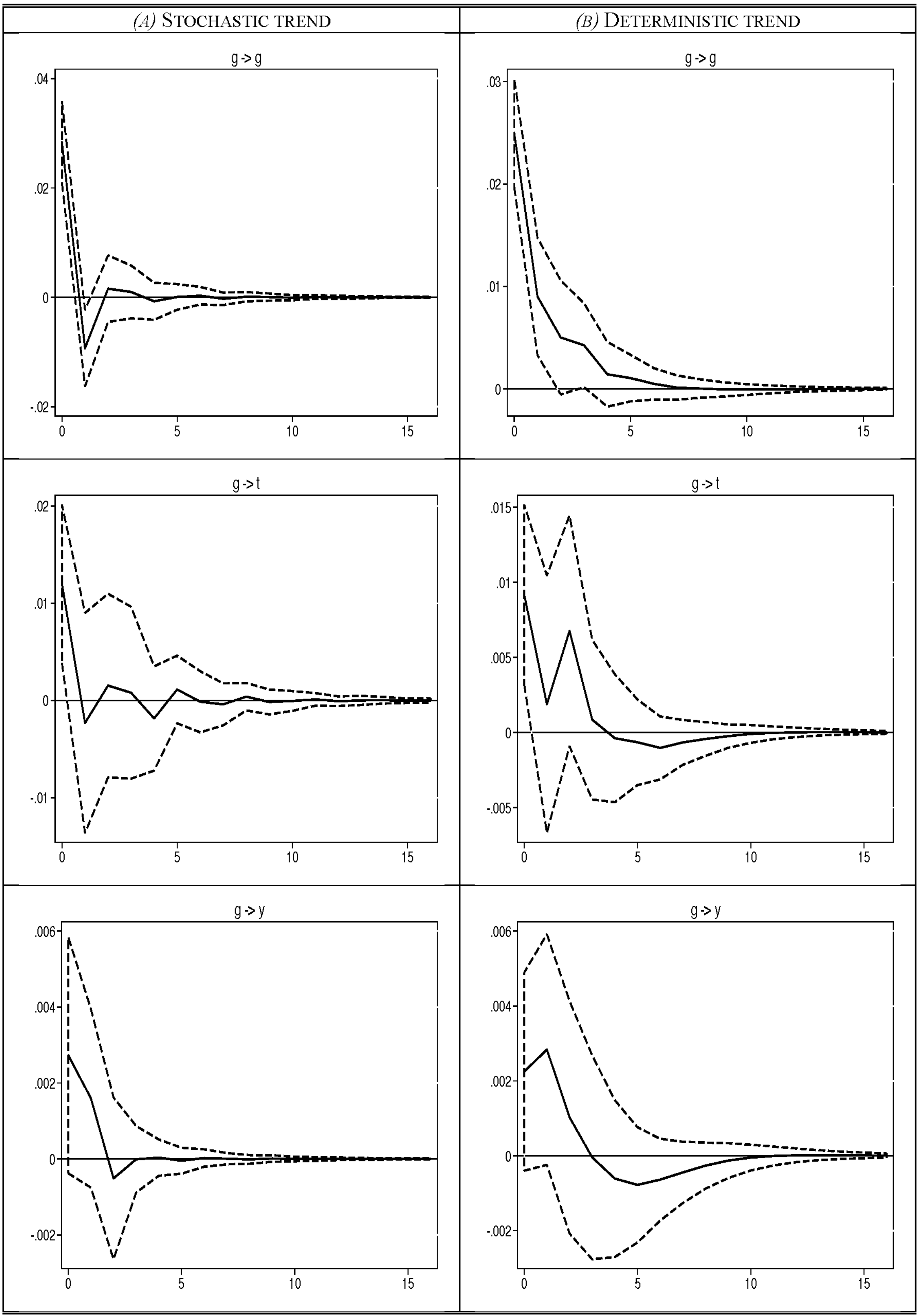

Figure [I-3] – Responses to spending shocks (recursive)
Notes: Bootstrap confidence intervals (400 replications).

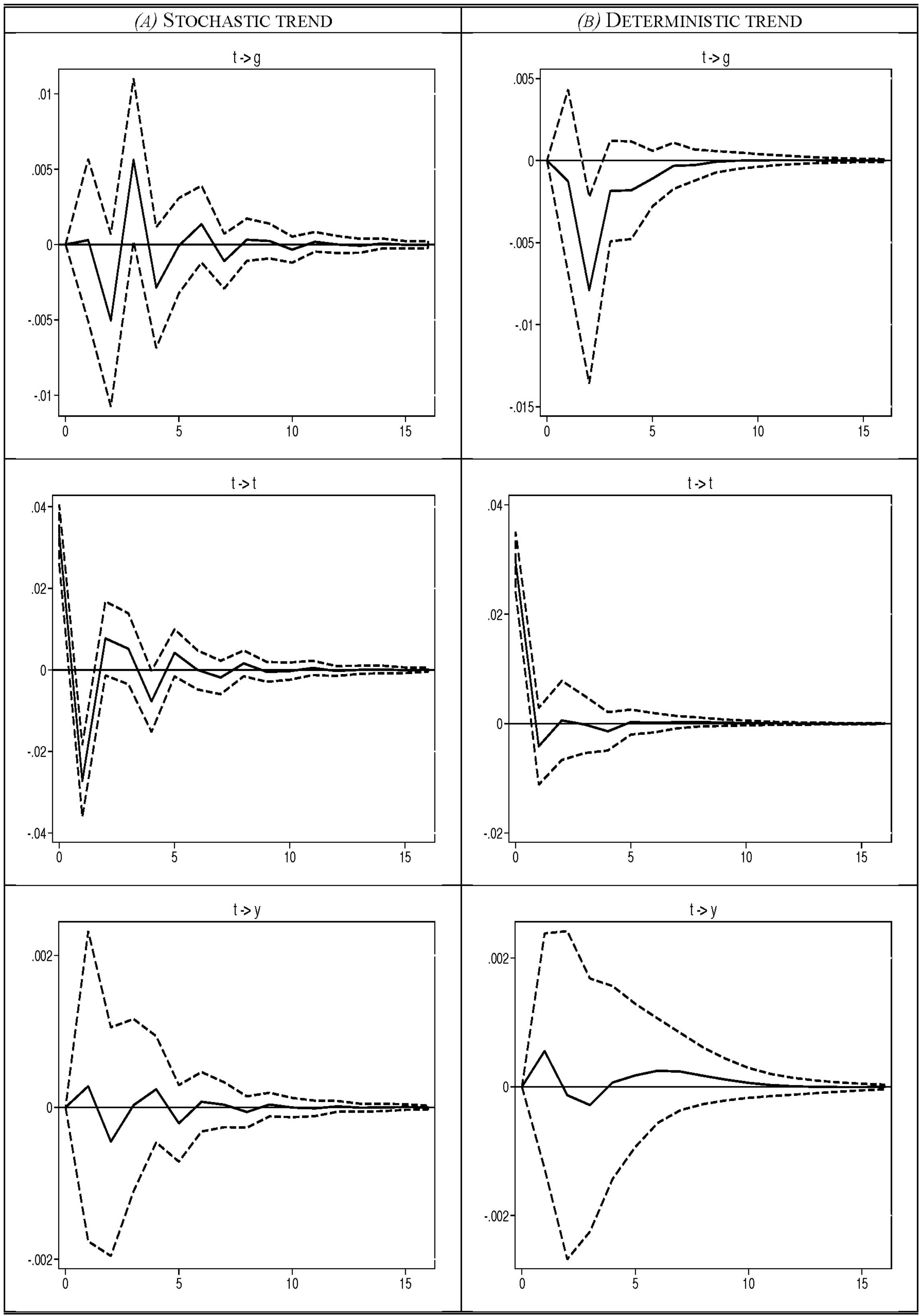

FIGURE [I-4] – RESPONSES TO TAX SHOCKS (RECURSIVE)
Notes: Bootstrap confidence intervals (400 replications).

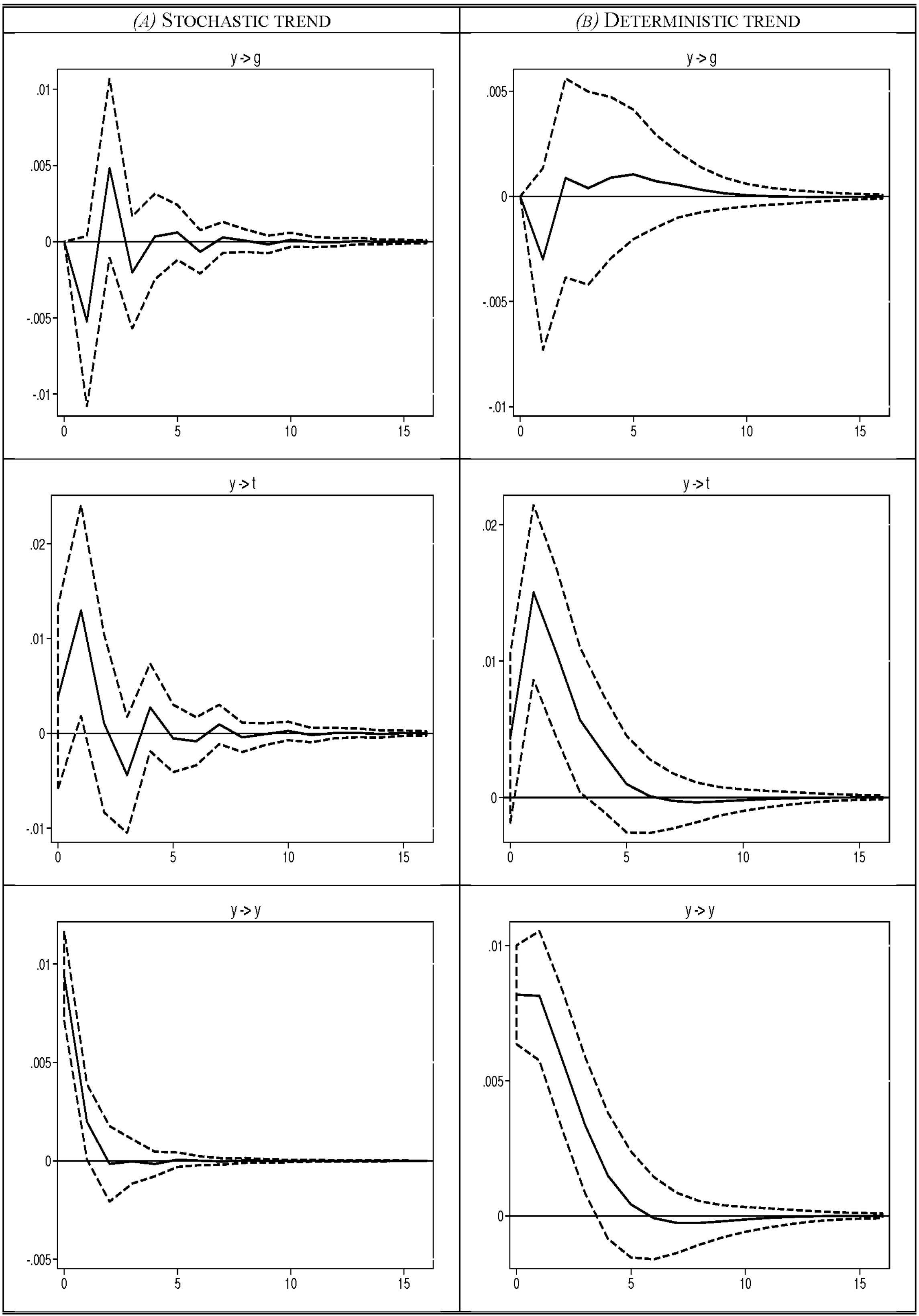

FIGURE [I-5] – RESPONSES TO OUTPUT SHOCKS (RECURSIVE)
Notes: Bootstrap confidence intervals (400 replications).

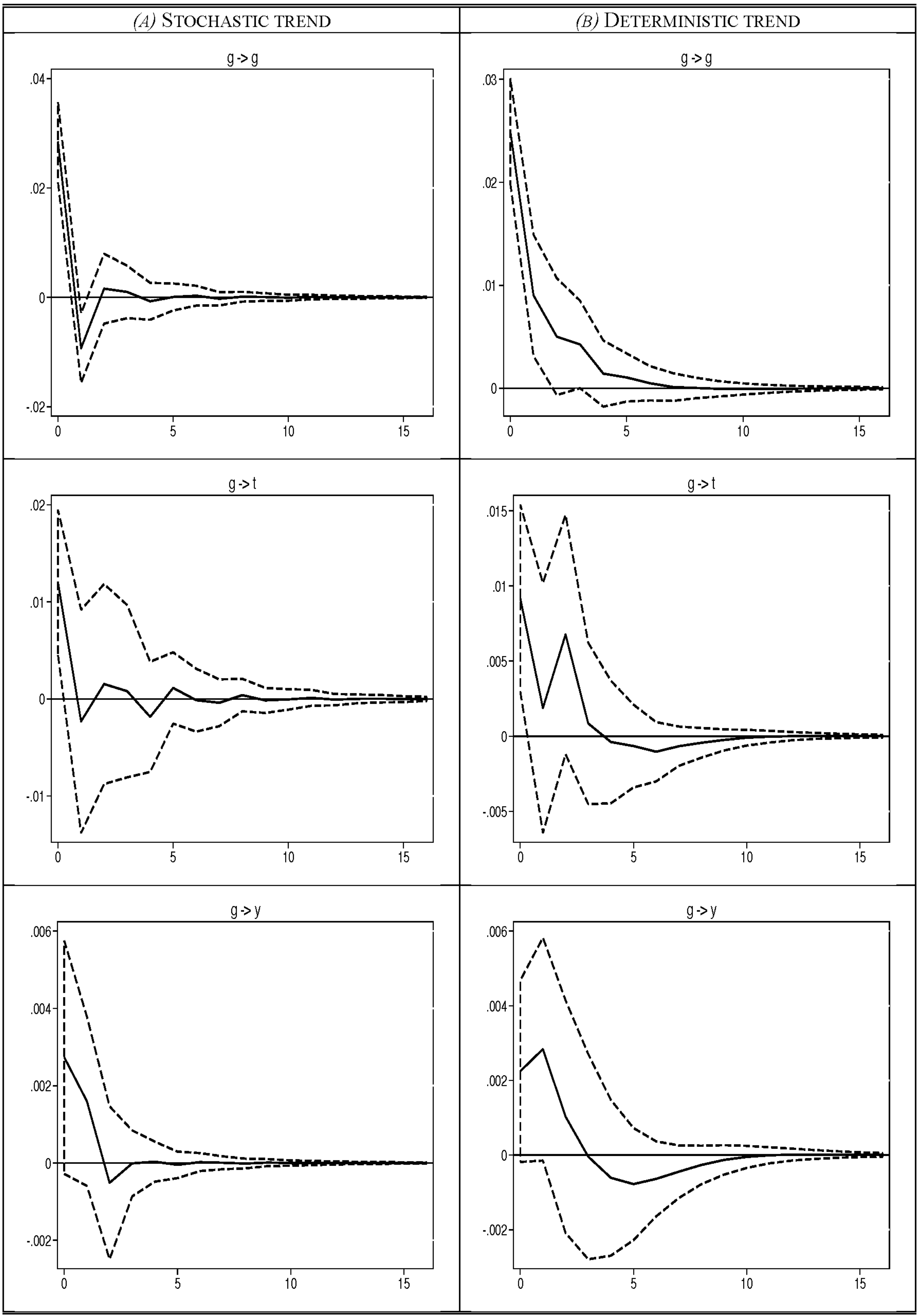

Figure [I-6] – Responses to spending shocks (structural)
Notes: Bootstrap confidence intervals (400 replications).

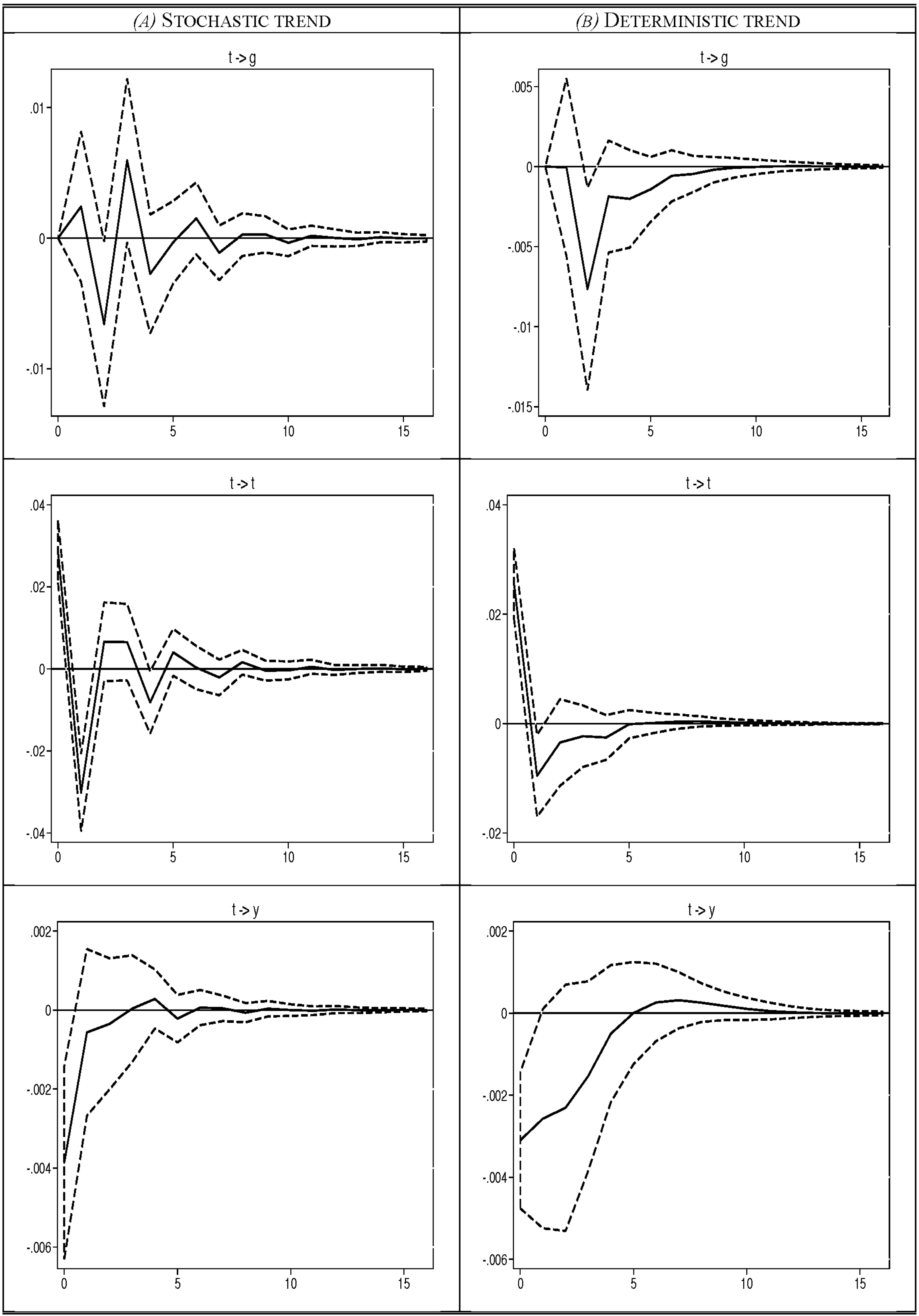

FIGURE [I-7] – RESPONSES TO TAX SHOCKS (STRUCTURAL)

Notes: Bootstrap confidence intervals (400 replications).

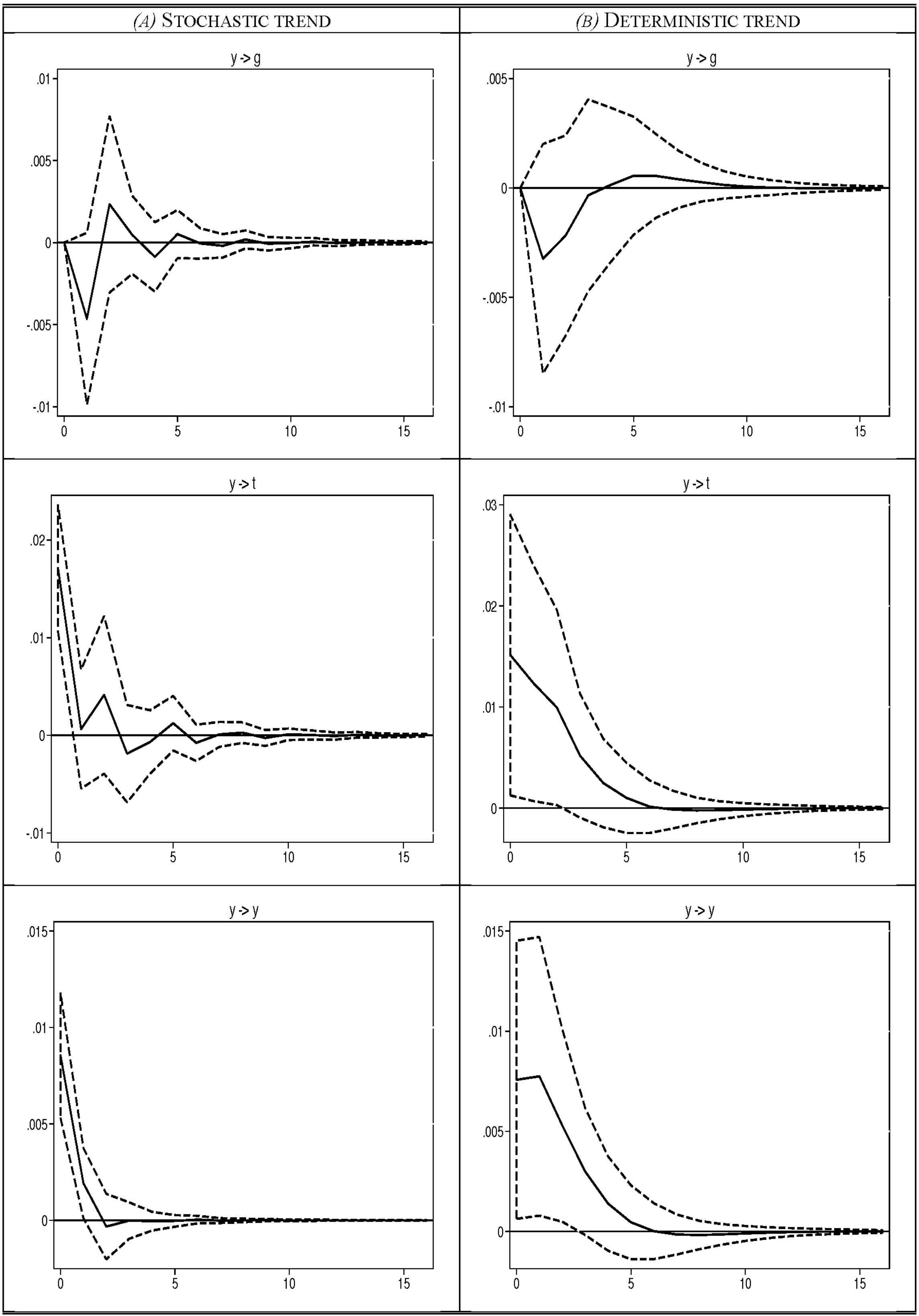

FIGURE [I-8] – RESPONSES TO OUTPUT SHOCKS (STRUCTURAL)
Notes: Bootstrap confidence intervals (400 replications).

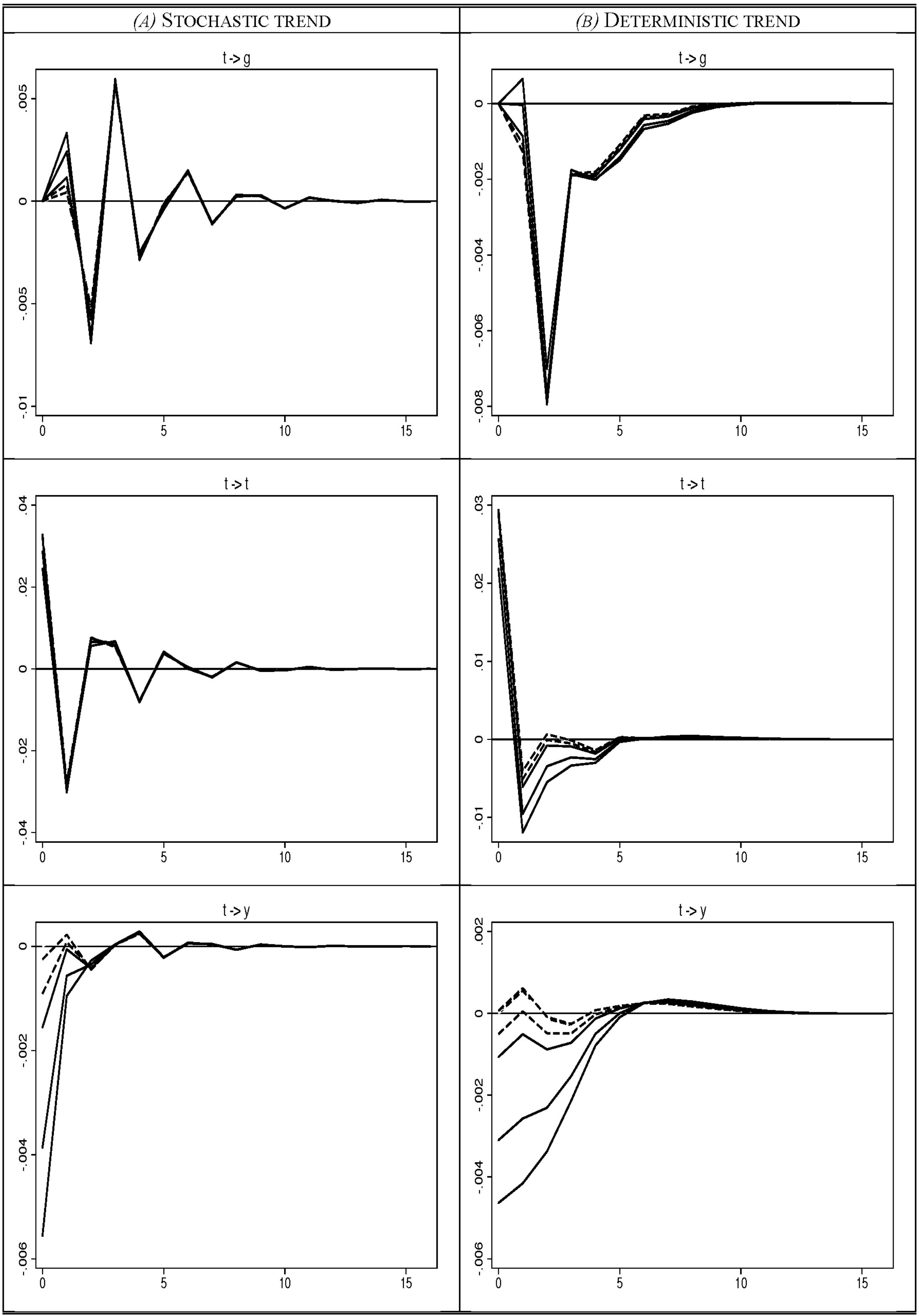

FIGURE [I-9] – RESPONSES TO TAX SHOCKS (ALTERNATIVE ELASTICITIES)

Notes: *dashed light-grey* – recursive model; *dashed dark*-grey represents the response of the structural model with $\alpha_{\tau y} = 0{,}5$; *dashed black*, $\alpha_{\tau y} = 0{,}75$; *solid light-red*, $\alpha_{\tau y} = 1$; *solid dark-red*, $\alpha_{\tau y} = 2$ and *solid black*, $\alpha_{\tau y} = 3$.

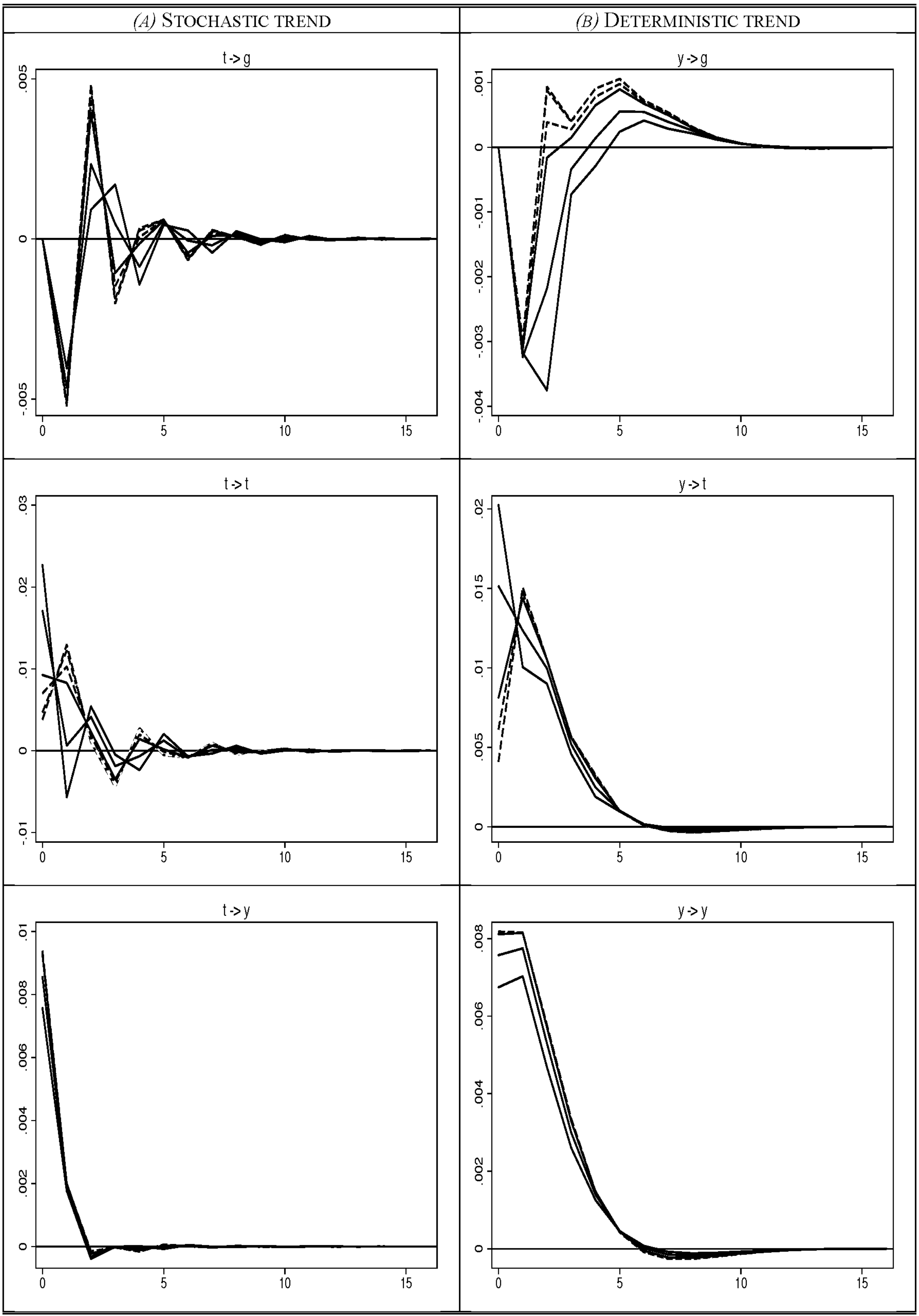

FIGURE [I-10] – RESPONSES TO OUTPUT SHOCKS (ALTERNATIVE ELASTICITIES)
Notes: *dashed light-grey* – recursive model; *dashed dark*-grey represents the response of the structural model with $\alpha_{\tau y} = 0{,}5$; *dashed black,* $\alpha_{\tau y} = 0{,}75$; *solid light-red,* $\alpha_{\tau y} = 1$; *solid dark-red,* $\alpha_{\tau y} = 2$ and *solid black,* $\alpha_{\tau y} = 3$.

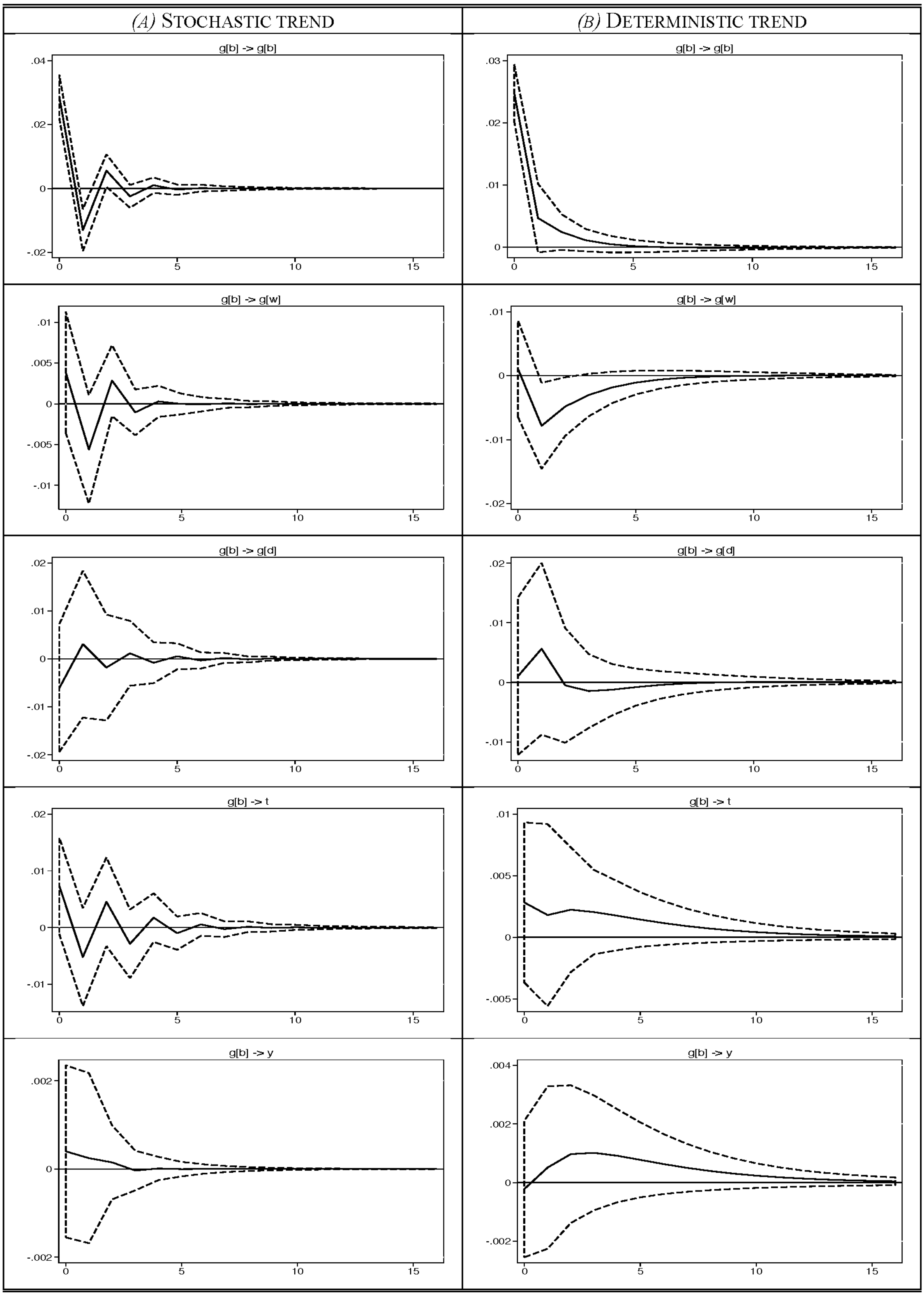

FIGURE [I-11] – STRUCTURAL RESPONSES TO BENEFITS SPENDING SHOCK
Notes: Bootstrap confidence intervals (400 replications).

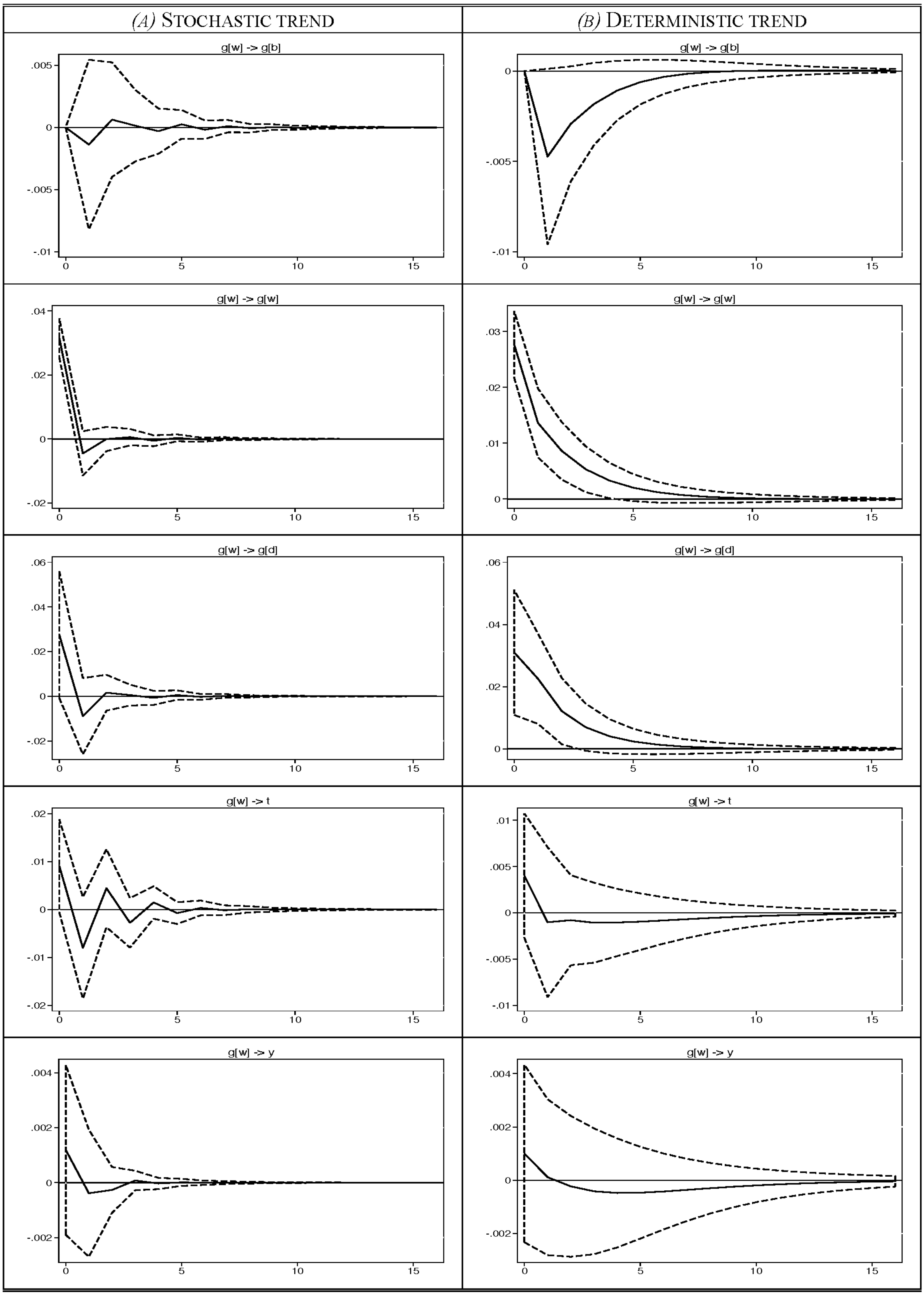

FIGURE [I-12] – STRUCTURAL RESPONSES TO WAGE SPENDING SHOCKS.
Notes: Bootstrap confidence intervals (400 replications).

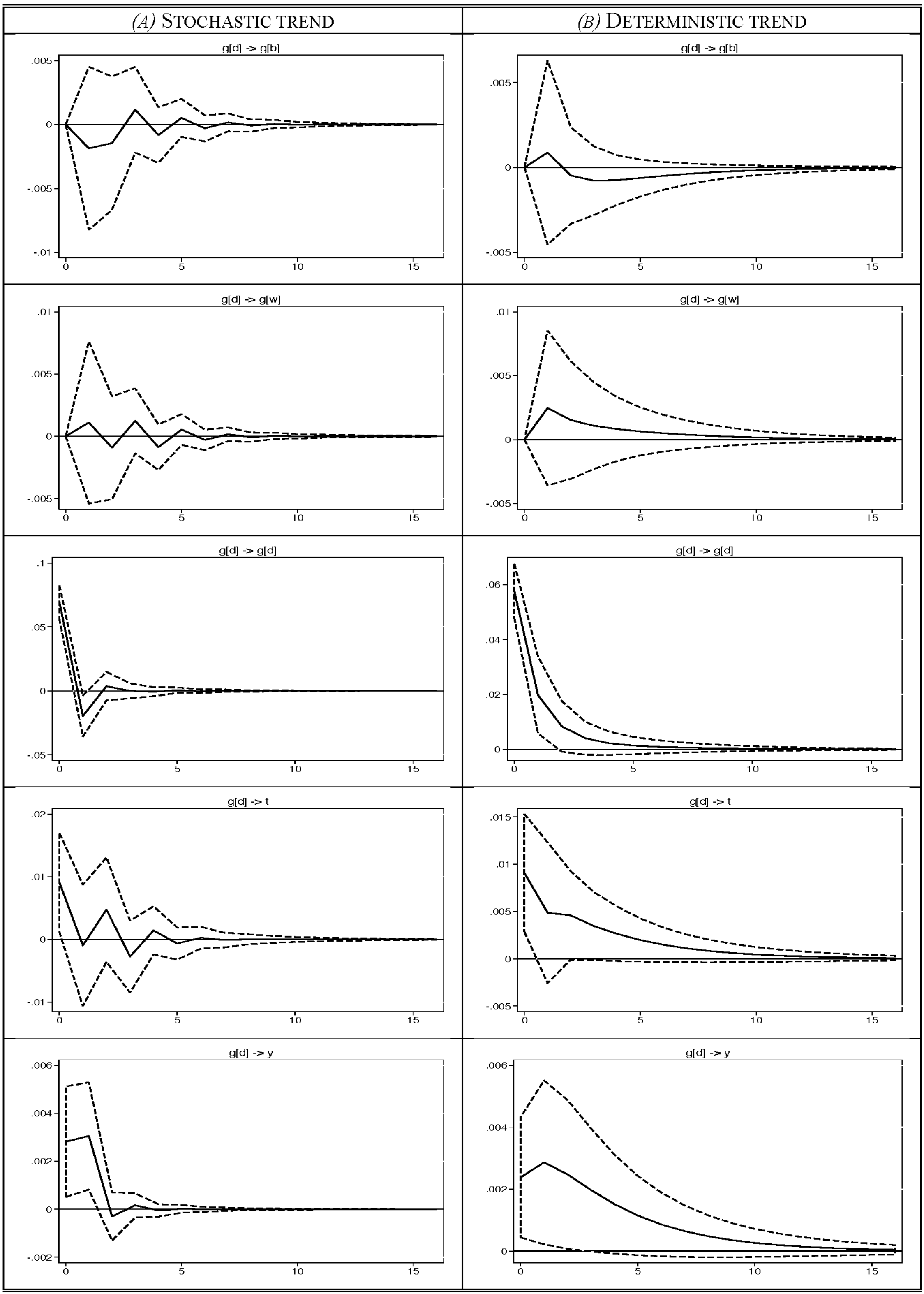

FIGURE [I-13] – STRUCTURAL RESPONSES TO DEFRAYAL SPENDING SHOCKS.
Notes: Bootstrap confidence intervals (400 replications).

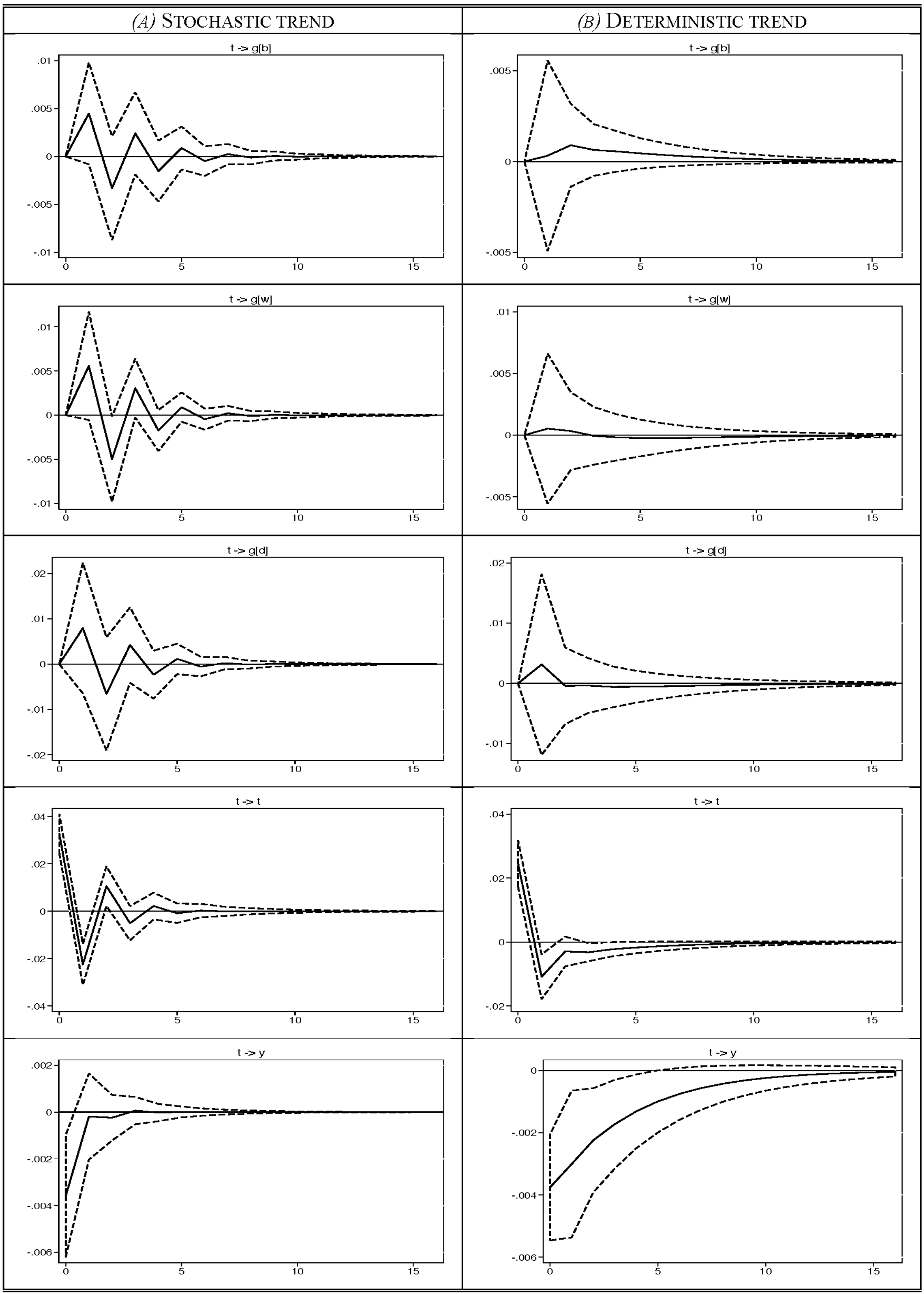

FIGURE [I-14] – STRUCTURAL RESPONSES TO TAX SHOCKS.
Note: Bootstrap confidence intervals (400 replications).

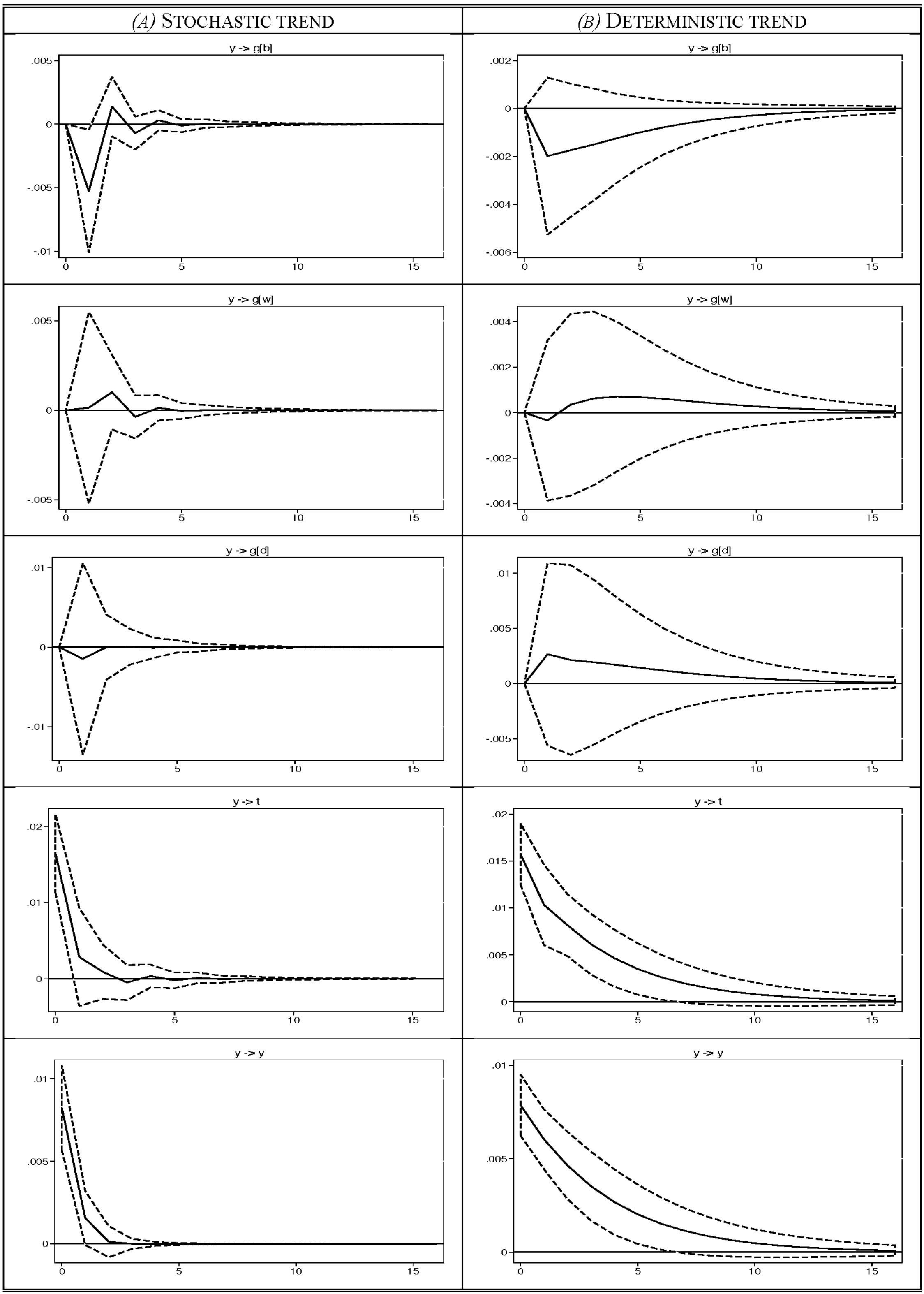

FIGURE [I-15] – STRUCTURAL RESPONSES TO AN OUTPUT SHOCK.
Source: Author's calculations.
Note: Bootstrap confidence intervals (400 replications).

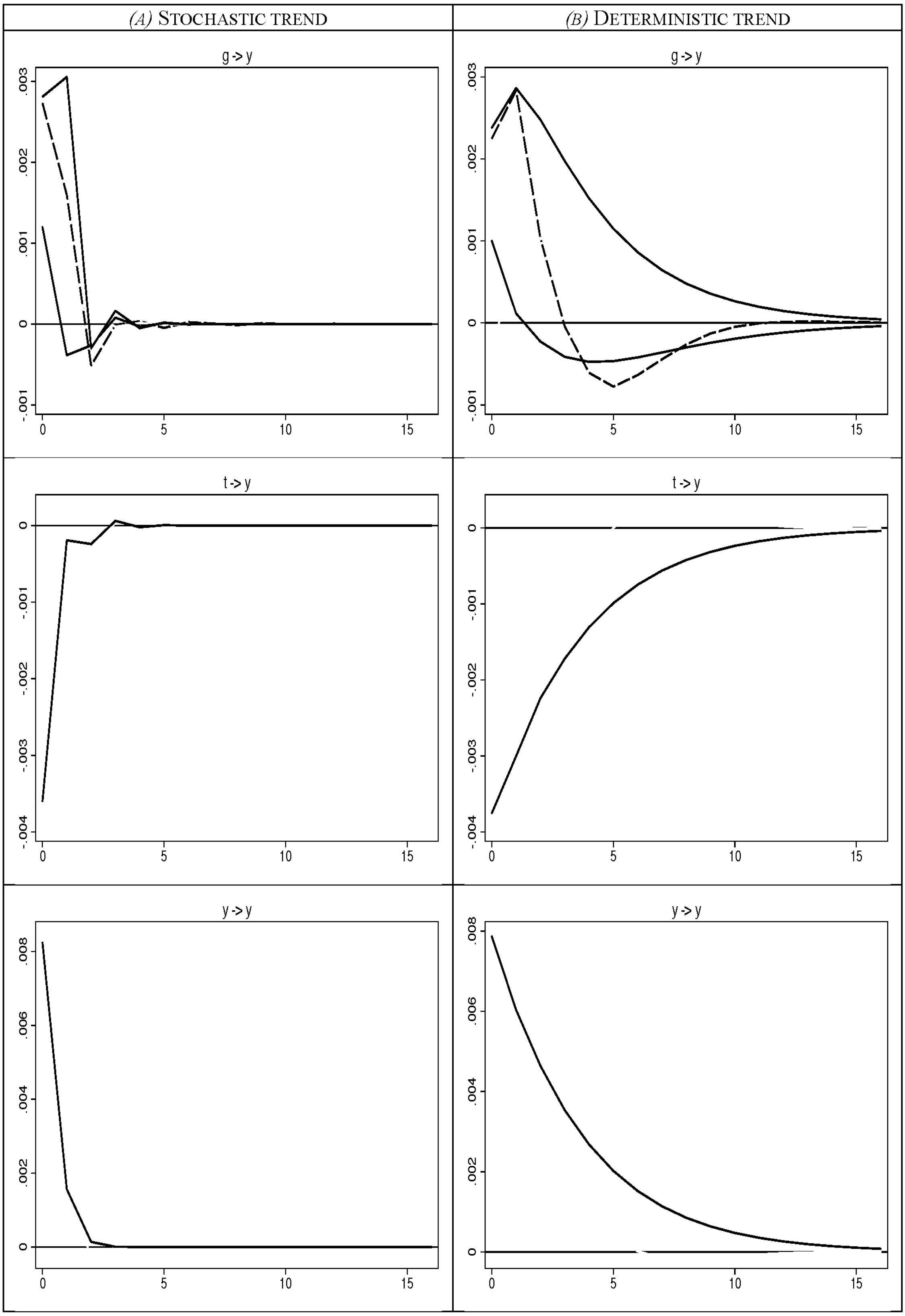

FIGURE [I-16] – COMPARISON OF SELECTED RESPONSES: BASIC VS. EXPANDED MODEL

Notes: **I)** First row: output's responses to shocks on overall spending [*dashed black*], benefits spending [*solid light-grey*], wage spending [*solid dark-grey*] and defrayal spending [*solid black*]. **II)** Second row: output's responses to tax shocks [basic model – *grey lines;* extended model – *black* lines]. **III)** Third row: output's response to its own shock [basic model – *grey lines*; extended model – *black lines*].

APPENDIX II

PART TWO'S IRFS

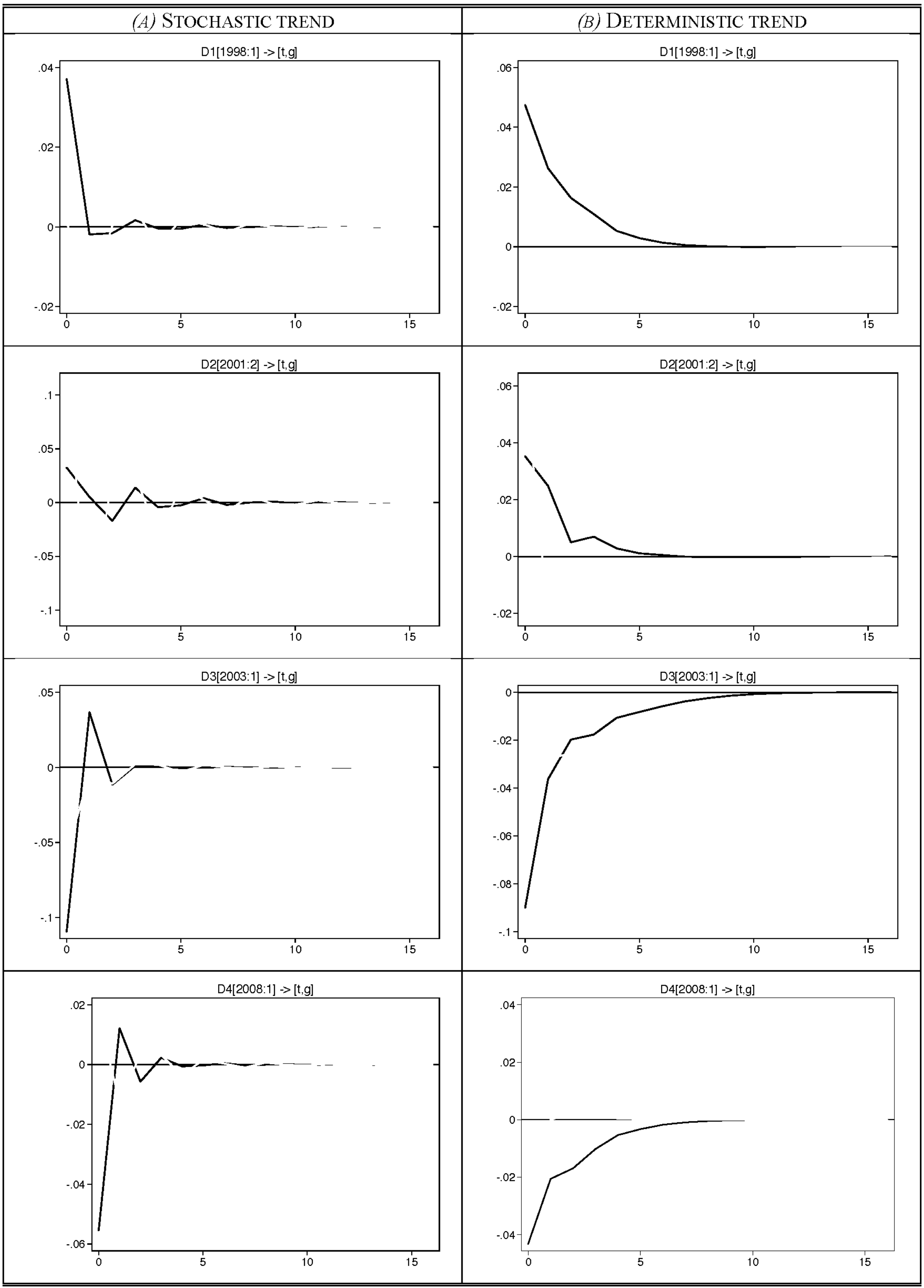

FIGURE [II-3] – SPENDING AND TAX RECEIPTS RESPONSES TO FISCAL EPISODES.

Note: Black lines: spending; grey lines; tax receipts (both impulse-responses functions are from the basic model).

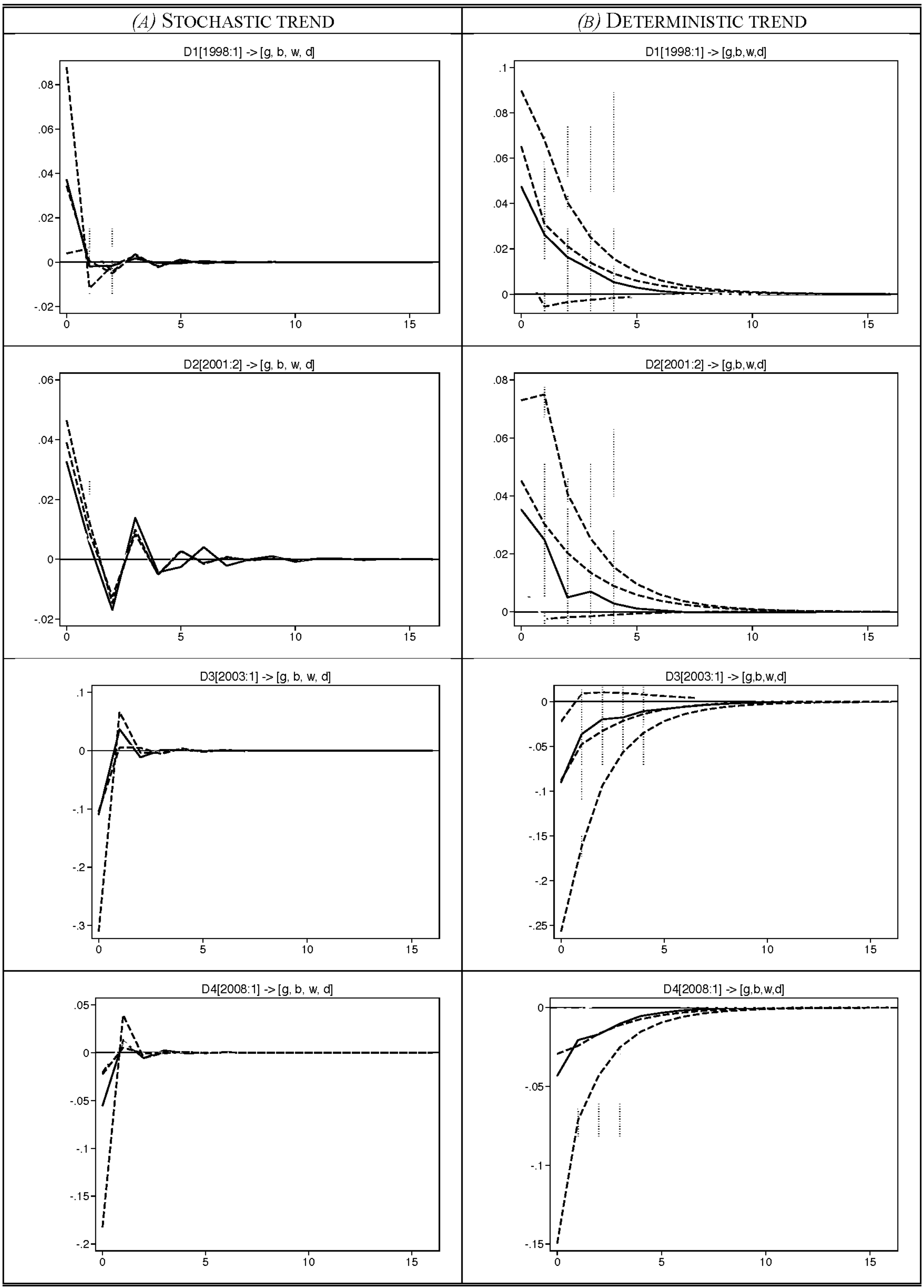

FIGURE [II-4] – SPENDING CATEGORIES RESPONSES TO FISCAL EPISODES.

Note: Total spending response in *solid black lines* (basic model); benefits responses in *solid grey* (extended model); wage response in *dashed black* (extended model) and defrayal response in *dashed grey* (extended model).

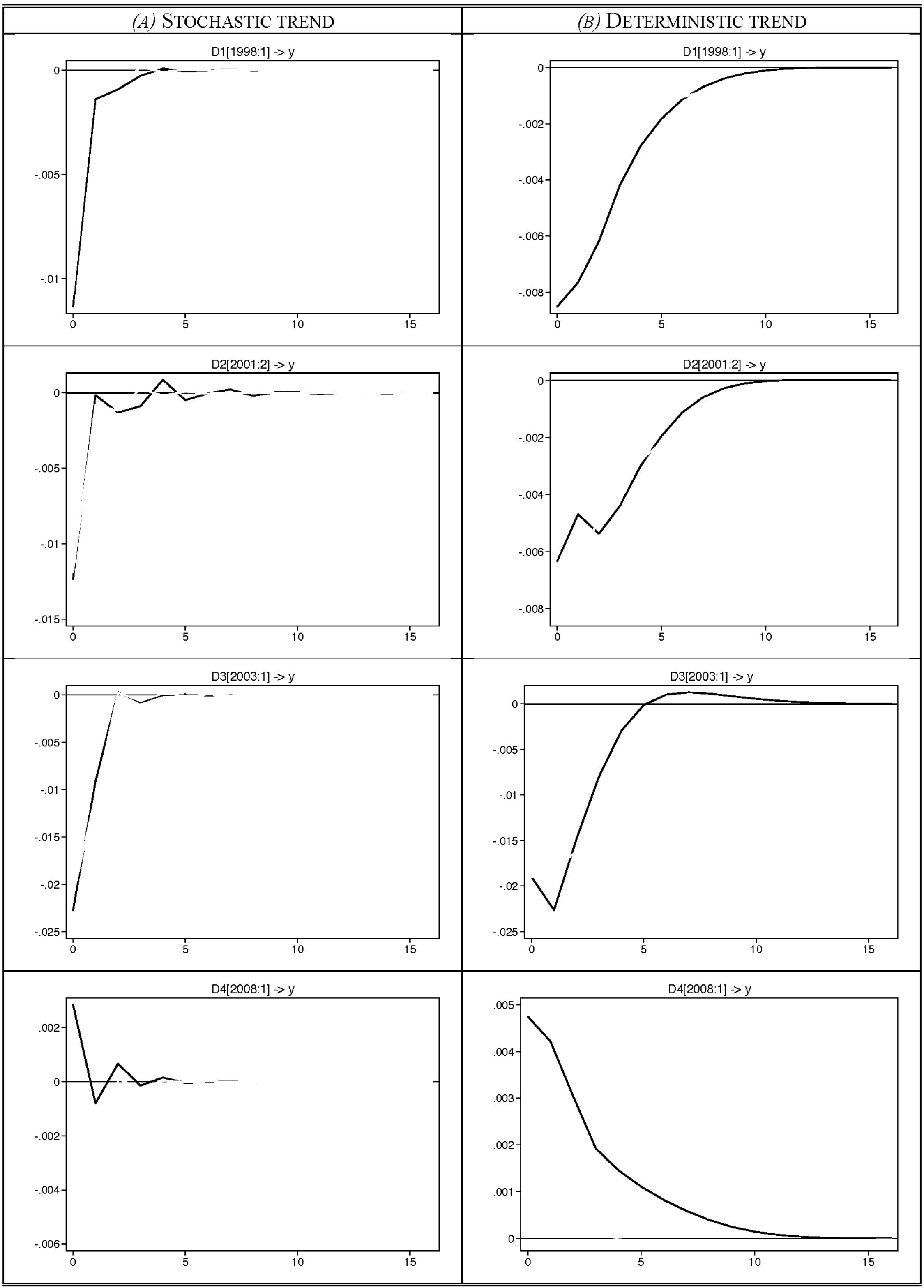

FIGURE [II-5] – OUTPUT RESPONSES TO FISCAL EPISODES.
Note: Basic model: *black lines*; extended model: *dashed black*.

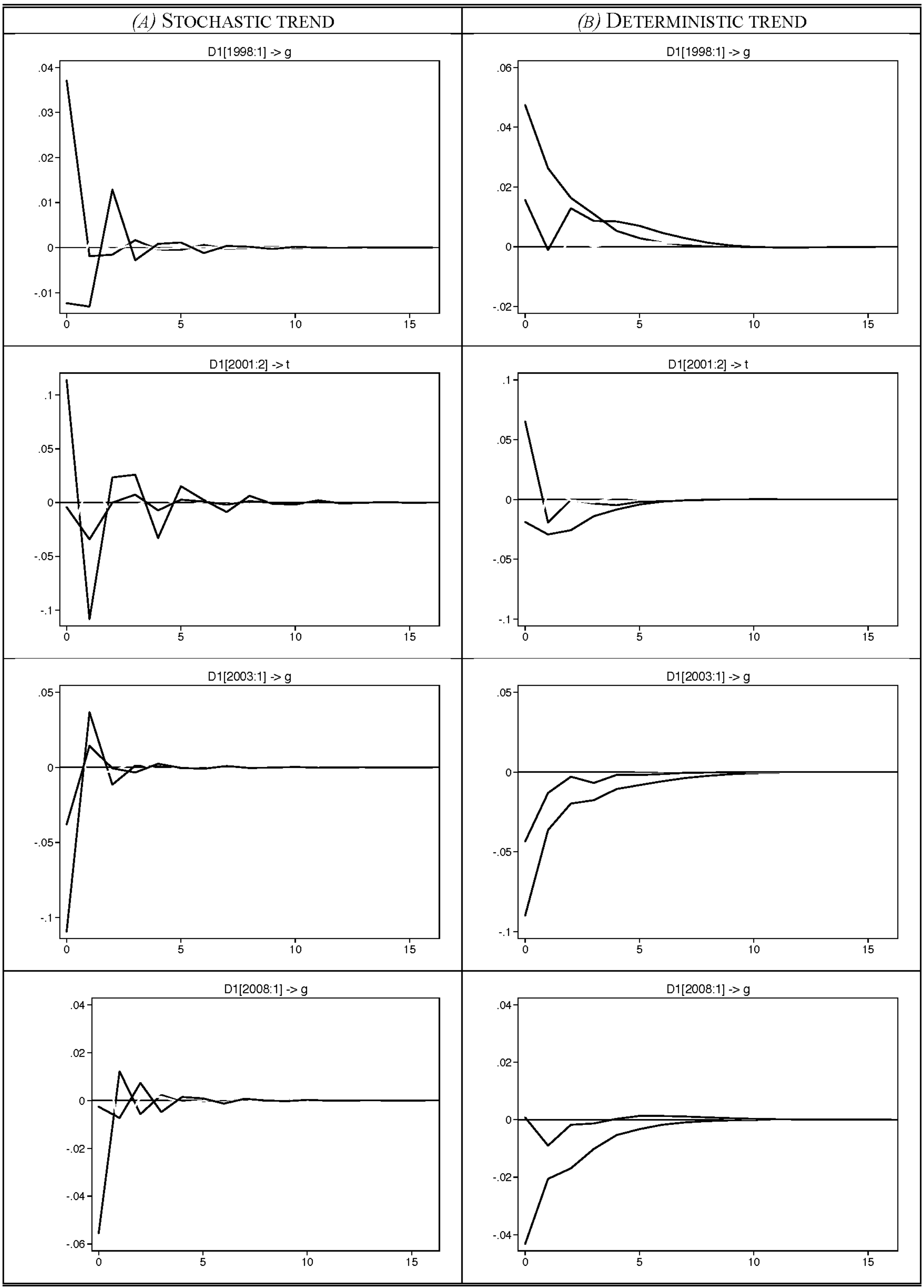

FIGURE [II-6] – ROBUSTNESS TESTS OF FISCAL EPISODES.
Note: *solid lines* represent the standard model (same as Figure [3]); *dashed lines* represent the model assuming that the fiscal episode in question takes place one quarter earlier; *dotted lines* represent the basic model assuming that the fiscal episodes takes place on quarter latter.

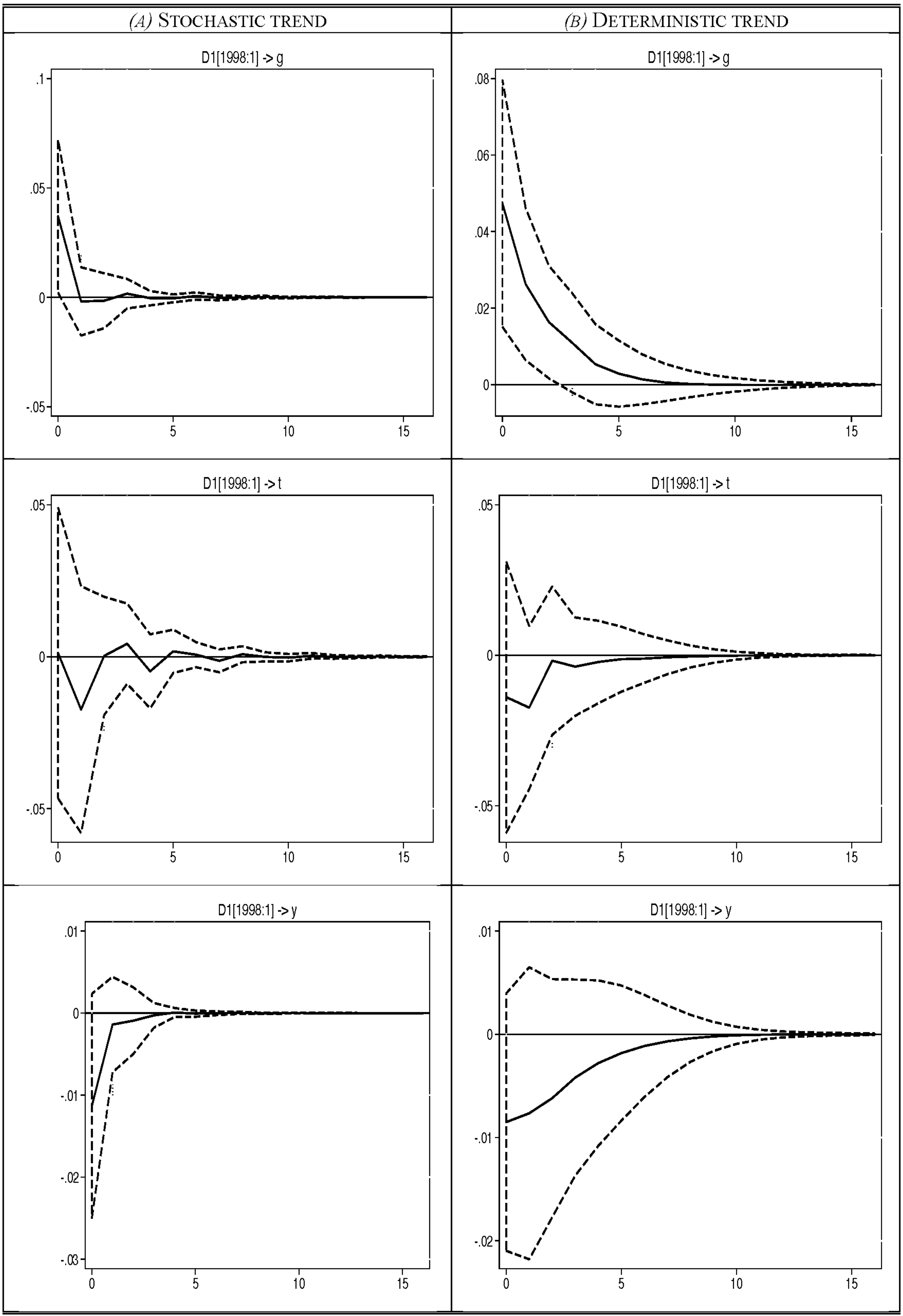

FIGURE [II-6] – IRFs FROM D1[1998:1] (BASIC MODEL).
Note: 95% confidence intervals.

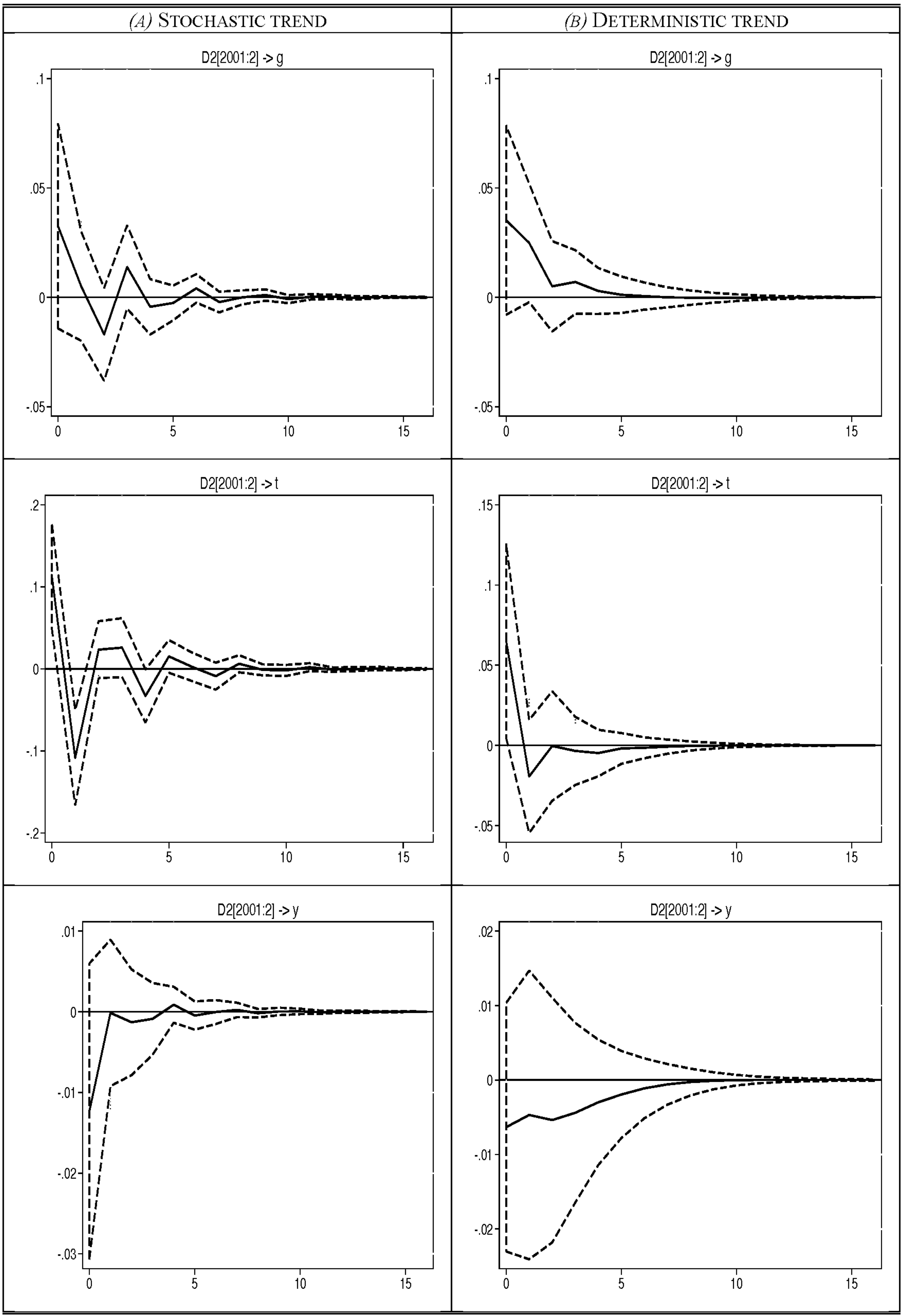

FIGURE [II-7] – IRFs FROM D2[2001:2] (BASIC MODEL).
Note: 95% confidence intervals.

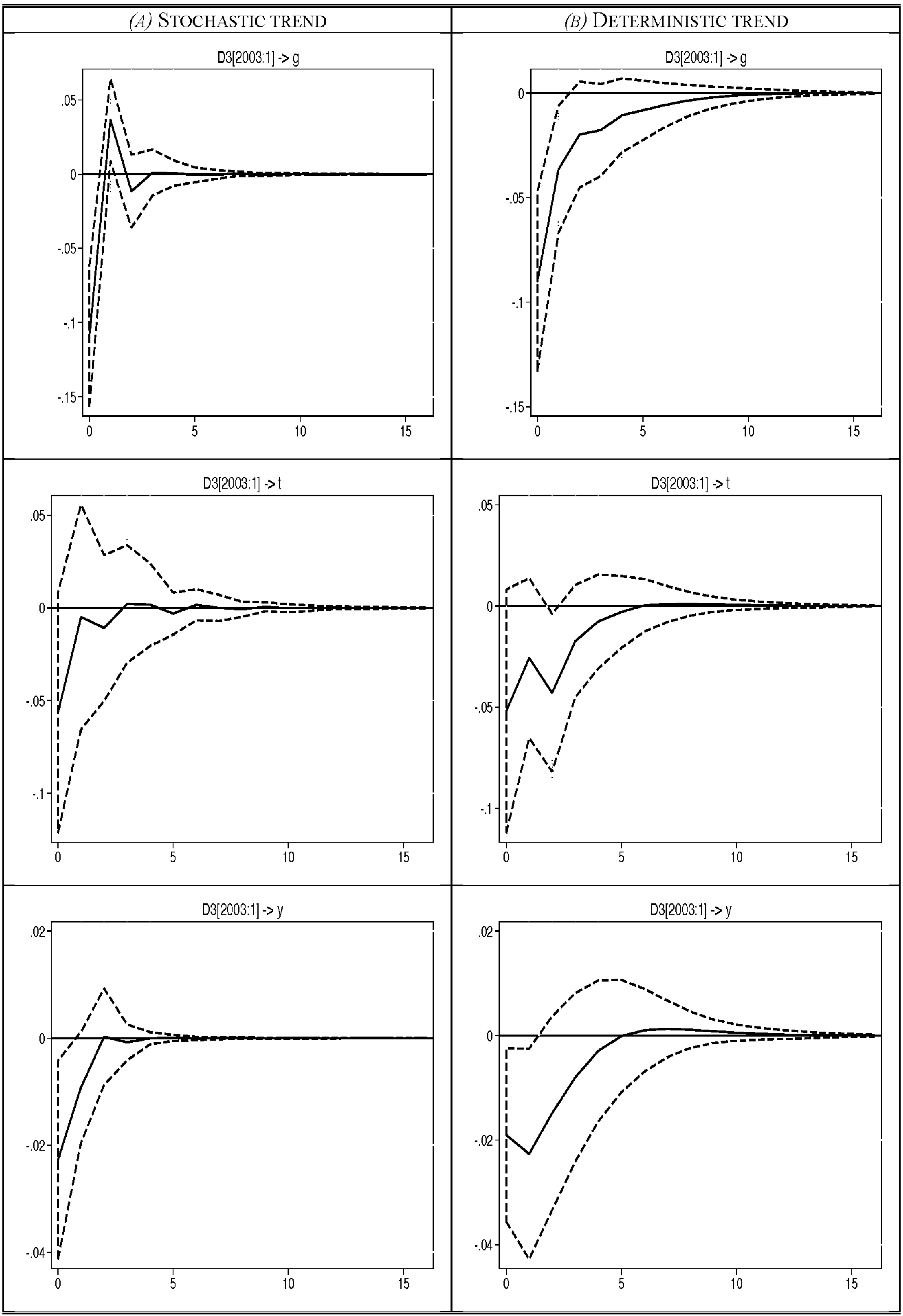

FIGURE [II-8] – IRFs FROM D3[2003:1] (BASIC MODEL).
Note: 95% confidence intervals.

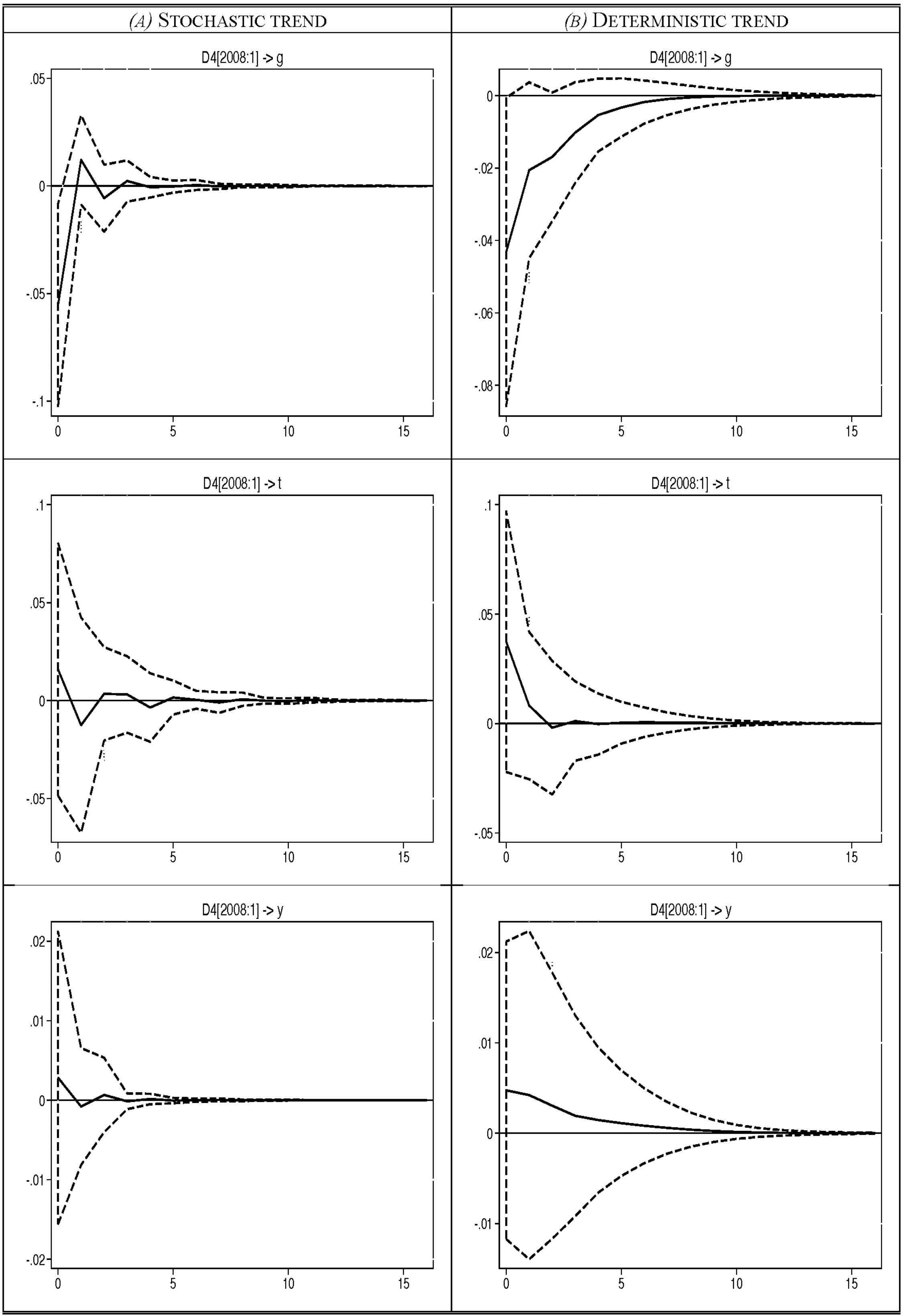

Figure [II-9] – IRFs from D4[2008:1] (Basic Model).
Note: 95% confidence intervals.

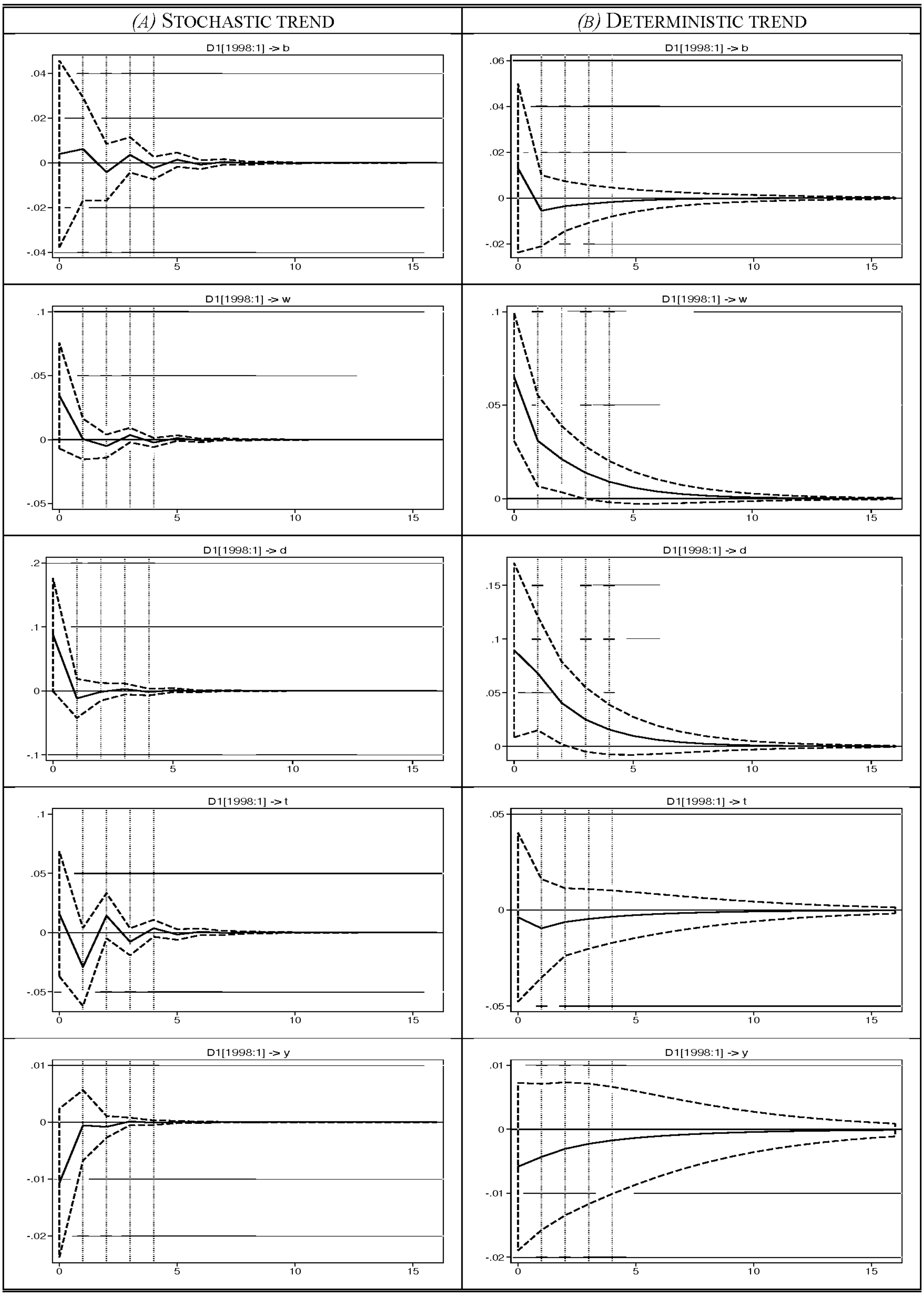

FIGURE [II-10] – IRFS FROM D1[1998:1] (EXTENDED MODEL).
Note: 95% confidence intervals.

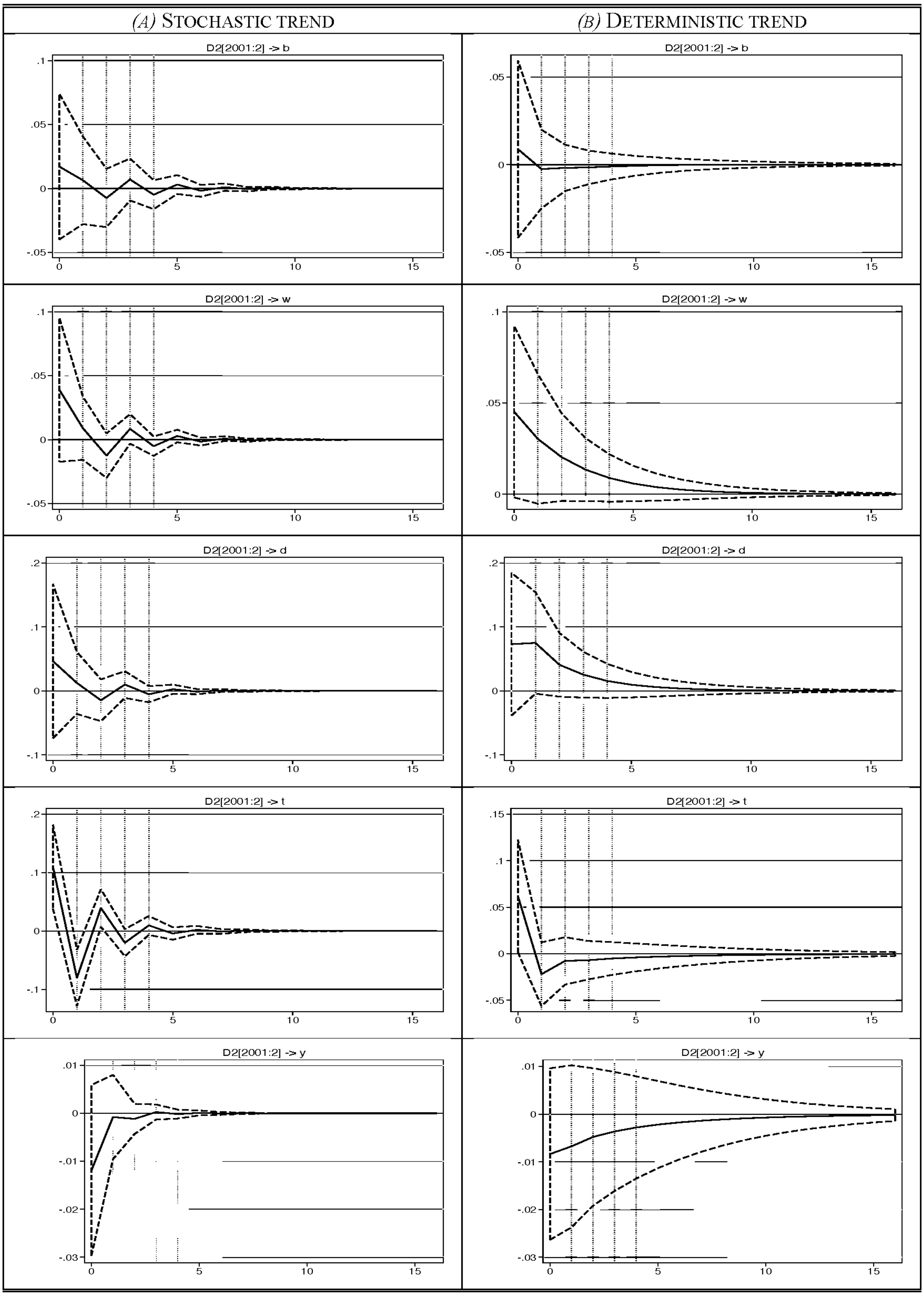

FIGURE [II-11] – IRFS FROM D2[2001:2] (EXTENDED MODEL).
Note: 95% confidence intervals.

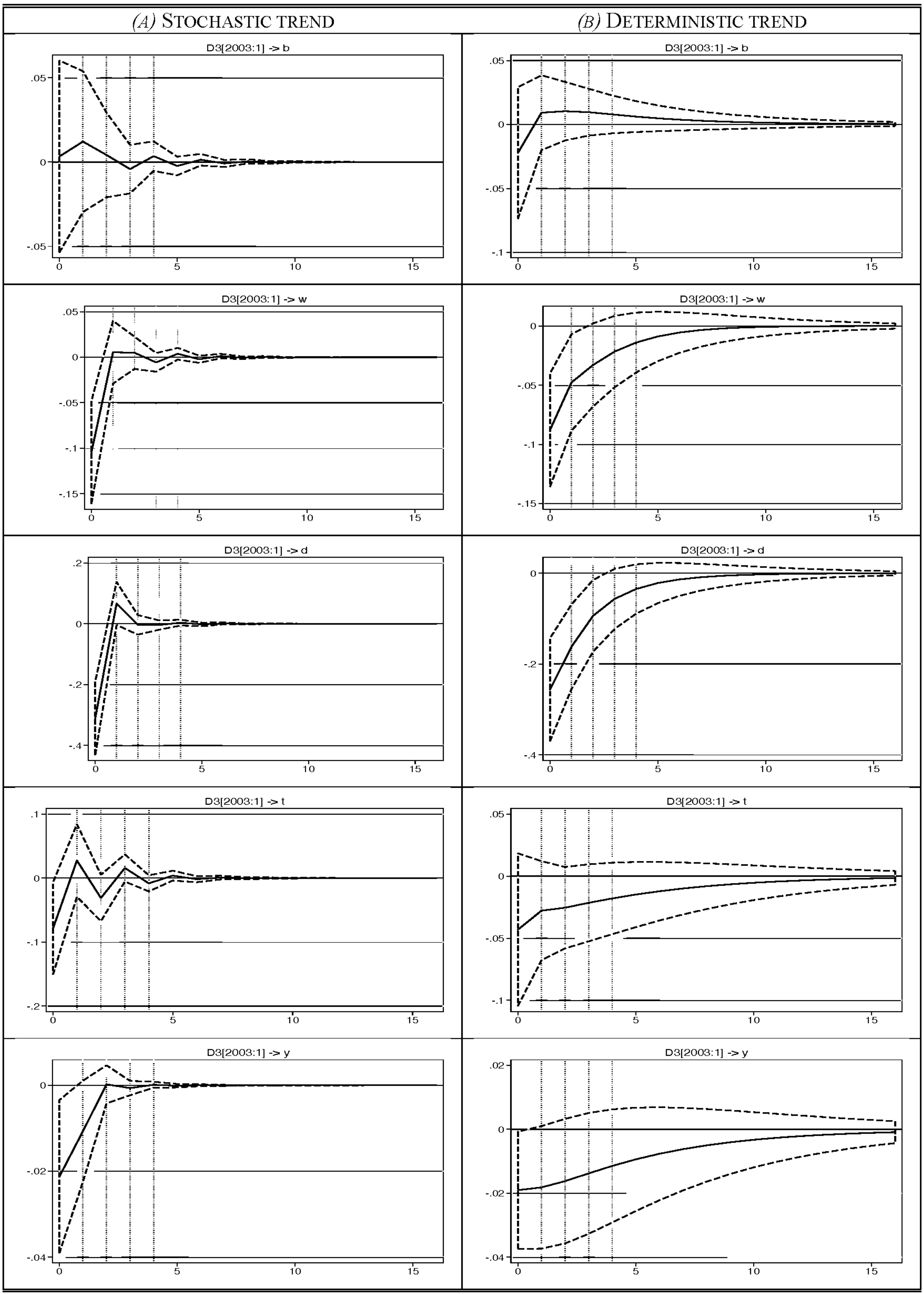

FIGURE [II-12] – IRFS FROM D3 [2003:1] (EXTENDED MODEL).
Note: 95% confidence intervals.

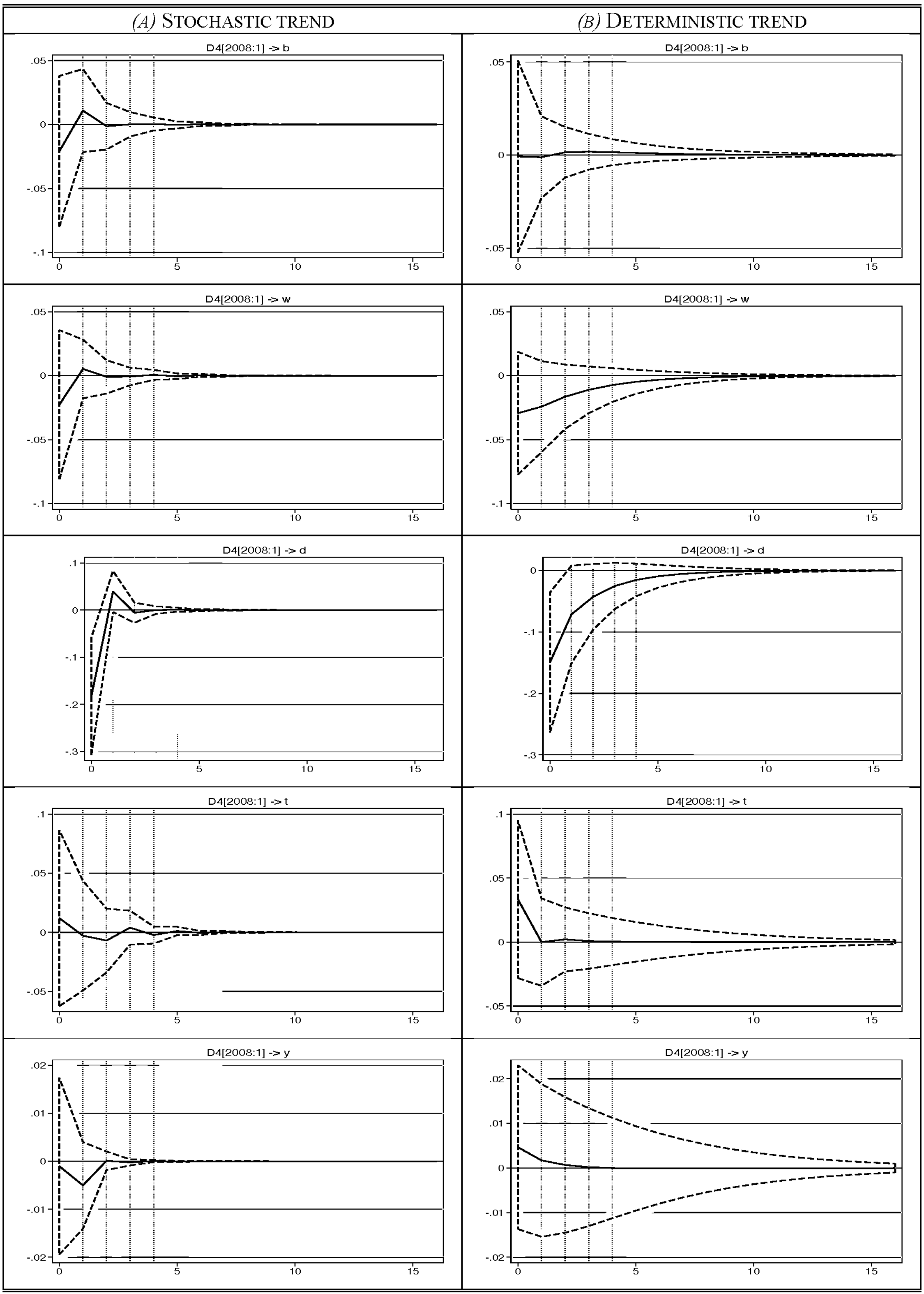

FIGURE [II-13] – IRFS FROM D4[2008:1] (EXTENDED MODEL).
Note: 95% confidence intervals.