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Brazilian economy in the 2000's: A tale of two recessions

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ABSTRACT

During the 2008 Great Recession, the adoption of counter-cyclical economic policies made the Brazilian economy more resilient. However, a noteworthy shift occurred in 2014, marked by a deterioration in Brazil's macroeconomic landscape, primarily driven by a worsening debt situation. Consequently, this downturn led to a decline in private investment, an upswing in unemployment rates, and negative growth rates over multiple quarters. To comprehend these macroeconomic fluctuations, this paper employs the Business Cycle Accounting (BCA) analytical framework, focusing on quarterly data spanning from 2002 to 2019. Among the key findings, the study reveals that the efficiency wedge played a pivotal role in replicating observed output movements during both recessions, with the labor wedge following closely. Investment and government consumption wedges were not significant business cycle drivers in the period.

1. Introduction

After troubled decades of high inflation, low economic growth and six monetary stabilization attempts, Brazil started the 2000s amid low economic growth rates. Since 2002, however, the country had experienced a positive economic cycle due to, among other factors, the favorable external environment and a commodity boom. In this context, the Brazilian economy experienced growth annual average of 3.9% between 2002 and 2010, above the 2.7% growth rate observed for the group of Latin American countries excluding Brazil.

Among the possible causes for this behavior, the adoption of counter-cyclical economic policies during the 2008 Great Recession stands out. Compared to developed countries, the Brazilian economy was little affected by adverse developments in the world economy, and presented average growth of 4.1% between 2008 and 2011, compared to 3.3% in the rest of the world.

From 2012 onwards, however, Brazil experienced a deterioration in its fiscal accounts and, contrary to the world trend, it entered one of the worst recessions in its history. The average annual growth of -2.1% and the increase in unemployment of 6.5% in 2012 to 12.0% between 2014 and 2016 reflect the severity of the crisis the Brazilian economy went through. As a result, the average growth was 0.7% per year from 2011 to 2019, compared to 2.0% of its Latin American peers.

Given this quick background, the present paper aims to quantitatively measure the economic distortions present in the Brazilian economy between 2002 and 2019. In addition, the objective is also to analyze the relative impacts on the product, hours worked and investment during the 2014 Crisis, and contrast them with the period of the 2008 Great Recession. For this, this paper uses the analytical framework of Business Cycle Accounting (BCA), developed by [Chari et al. \(2007\)](#).

BCA captures short-term economic fluctuations and contrasts them with a “prototype model of economic growth”, which contains frictions or wedges that vary over time and that have functions similar to the functions of productivity (efficiency wedge), labor tax (labor wedge), tax on investment (investment wedge) and government spending (government wedge), in affecting the optimal

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decisions of families and firms. Each wedge acts in a specific micro-founded decision of the model: production, intratemporal choice between work and leisure, an intertemporal Euler equation, and a budget constraint, respectively.

By construction, the wedges are able to jointly reproduce the variables observed from the model. Thus, a linear decomposition is performed after the estimation of wedges in order to determine which wedge, or which combination of wedges, is most relevant to explain observed economic fluctuations. For this, simulations of the variables of interest are performed by allowing only one wedge to vary at a time and keeping all the others constant and equal to their steady-state values. From the comparison of these simulations, it is possible to determine the relative importance of each distortion (Brinca et al., 2024).

As highlighted by Chari et al. (2007), BCA, in addition to the dimension of wedge accounting, described above, is also useful to guide researchers in the work of identifying relevant distortions to explain economic fluctuations in neoclassical growth models. Once identified, it is possible to select promising models capable of capturing the relevant wedges to the detriment of less promising ones. Brinca et al. (2024) survey the literature establishing equivalences from the mapping of wedges and several more detailed model frictions.

Our paper does not contribute to this methodological and theoretical literature which focuses on establishing equivalences between wedges and frictions in detailed models. Our paper is empirical and it contributes to the literature in two ways: (1) it provides a quantitative analysis of the economic distortions experienced by the Brazilian economy between 2002 and 2019, focusing on the recessions of 2008 and 2014; and (2) it determines the main distortions capable of capturing product movements, hours worked and investment, in order to identify the most suitable class of models to explain the fluctuations of the analyzed period.

Brinca et al. (2016) applied BCA to analyze the Great Recession of 2008 in OECD countries. The authors concluded that, with the exception of the United States, Spain, Ireland and Iceland, the efficiency wedge was able to better explain the fluctuations in the Great Recession. They also find that the labor wedge plays a dominant role only in the United States, and the investment wedge plays a dominant role in Spain, Ireland, and Iceland. Our paper provides an interesting contrast of the Great Recession from the perspective of a large emerging market like Brazil.

Our paper also contributes to the study of business cycles in Brazil and it is especially related to those sharing the same BCA methodology as ours (Graminho, 2006; Lama, 2011; Chakraborty and Otsu, 2013; Manfredini, 2020; Brinca and Costa-Filho, 2022). Graminho (2006) analyzed the economic fluctuations experienced by Brazil between 1980 and 2000 under the traditional BCA framework and concluded that productivity shocks were able to better explain the fluctuations in output, investment, and consumption in the 1980 decade. Among the factors that may have contributed to this, according to the author, are the creation of state-owned companies and a more closed economy in response to the oil shock of 1974, whose consequences were the creation of barriers to entry imposed on foreign competition and less efficient capital production. As for the period from 1990 to 2000, Graminho (2006) suggests that the labor wedge was able to better explain the fluctuations of the variables under study. According to the author, this occurs because there is evidence of technological improvement as a result of trade liberalization, as well as an increase in distortions in the labor market after the enactment of the 1988 Brazilian Constitution.

Lama (2011) adopts an open economy version of the prototype growth model with four wedges (efficiency, labor, capital, and bond) developed by Chari et al. (2005) to study output fluctuations in Brazil and other Latin American countries (Argentina, Chile, Colombia, Mexico, and Peru) for the 1991 to 2006 period. The author reports that the efficiency and labor wedges account for most of output drops in Brazil and in other Latin American countries. On the other hand, capital and bond wedges play minor roles in explaining episodes of output drops in the region.

Chakraborty and Otsu (2013) use BCA to study output fluctuations in Brazil and other BRIC countries (Russia, China, and India) for the 1990–2009 period. For the entire period, the contribution of labor wedges to output fluctuations is the most significant (49%), followed by investment (36.8%), and efficiency (29.3%) wedges. In the 2000s, the contribution of efficiency wedges rose to 93.2% of output fluctuations.

Compared to these previous BCA studies for Brazil our contribution is to investigate some more recent historical episodes and to use quarterly data. The papers closest to ours are Manfredini (2020) and Brinca and Costa-Filho (2022). As in Lama (2011), Manfredini (2020) considers an open economy prototype growth model with four wedges (bonds, efficiency, labor, and capital) to study business cycle fluctuation in Brazil for the 2003–2017 period. The author finds that efficiency is the main wedge accounting for the behavior of output, investment, and consumption, especially until 2009. After the Global Financial Crisis and mainly during the 2014–2016 recession, the labor wedge gradually gained importance, although the efficiency wedge remains the most important one.

Like our paper, Brinca and Costa-Filho (2022) also studied the 2014 recession through the lens of BCA methodology. The authors find that the efficiency wedge accounts for nearly all the output fluctuations during this episode with only marginal contributions from the other wedges. Brinca and Costa-Filho (2022) complement their study showing econometric evidence that the efficiency wedge is negatively related to earmarked credit expansion by the public development bank BNDES. Our results are quantitatively different from them with a more important role for the labor wedge due to differences in the sample period and in the data treatment.

Among our key findings, this study reveals that the efficiency wedge played a pivotal role in replicating observed output movements during the recessions of 2008 and 2014, with the labor wedge following closely. On the other hand, investment and government consumption wedges play no significant role in the business cycle fluctuations related to these recessions.

The text is organized as follows. Section 2 details the analytical framework on which our paper is based, and is subdivided in order to present the model (Section 2.1), the computation of the wedges (Section 2.2), the data (Section 2.3) and the parameters used (Section 2.4). Later, in Section 3, Sections 3.1 and 3.2 discuss the main results on the behavior of the modeled distortions and on the contrast between the episodes covered, respectively. Finally, Section 4 presents the final considerations.

2. Methodology

This paper makes use of the methodological framework developed by Chari et al. (2007), which consists of an analytical framework capable of associating the short-term fluctuations observed in an economy to certain distortions, represented by the wedges. In a canonical neoclassical model of growth, wedges are introduced associated with productivity, labor, investment and government spending in the economy. Then, they are inserted individually as well as jointly in the model in order to analyze their marginal and joint contribution to explain the patterns in the data. The model is described in the sequence.

2.1. Model

Our framework closely follows Chari et al. (2007). The representative family is an expected utility maximizer. Household preferences depend positively on per capita consumption, c_t , and negatively on per capita labor, l_t , and are discounted over time by a factor $0 < \beta < 1$. N_t denotes the working-age population of the economy, which grows at the rate g_n . The family solves the following intertemporal problem:

$$\max_{\{c_t, x_t, l_t\}} E \sum_{t=0}^{\infty} \beta^t [\ln(c) + \psi \ln(1-l)] N_t \quad (1)$$

subject to the constraints

$$c_t + (1 + \tau_{xt})x_t = r_t k_t + (1 - \tau_{lt})w_t l_t + T_t \quad (2)$$

$$(1 + g_n)k_{t+1} = (1 - \delta)k_t + x_t \quad (3)$$

where x_t , k_t , r_t , w_t and T_t denote, respectively, per capita investment, per capita capital level, capital rental rate, wage, and lump-sum tax in a given period t of the economy. Furthermore, τ_{xt} and τ_{lt} denote taxes on investment and labor, respectively. $\psi > 1$ denotes a parameter of preference for leisure over labor and $0 < \delta < 1$ is the capital stock depreciation parameter.

The representative price-taking firm must choose the optimal quantities of aggregate capital, K_t , and aggregate labor, L_t , that it will acquire to maximize its profit. In addition, the government must satisfy the following budget constraint:

$$g_t + T_t = \tau_{lt} w_t l_t + \tau_{xt} x_t \quad (4)$$

where g_t denotes government spending.

In equilibrium, the following first-order conditions and resource constraint must hold:

$$\hat{y}_t = A_t \hat{k}_t^\theta (z_t l_t)^{1-\theta} \quad (5)$$

$$\frac{\psi \hat{c}_t}{1 - l_t} = (1 - \tau_{lt})(1 - \theta) \frac{\hat{y}_t}{l_t} \quad (6)$$

$$\frac{(1 + \tau_{xt})}{\hat{c}_t} = \beta E_t \frac{1}{\hat{c}_{t+1}} \left[\theta \frac{\hat{y}_{t+1}}{\hat{k}_{t+1}} + (1 - \delta)(1 + \tau_{xt+1}) \right] \quad (7)$$

$$\hat{c}_t + \hat{g}_t + \hat{x}_t = \hat{y}_t \quad (8)$$

where z_t is labor-augmenting technological progress, which is supposed to grow at the rate g_z and A_t is a stochastic TFP component. $0 < \theta < 1$ denotes the share of capital in the economy's income. Furthermore, for any variable u , one defines its stationary version $\hat{u}_t \equiv \frac{u_t}{z_0(1 + g_z)^t}$.

Each of the four equations above is related to some particular wedge. Eq. (5) represents a Cobb–Douglas production function from which the efficiency wedge A_t is extracted. Improvements (reductions) in A_t are seen as increments (reductions) in the efficiency wedge. Eq. (6) combines the labor supply decision of households with the labor demand decision of firms. This equation allows to obtain the labor wedge given by $(1 - \tau_{lt})$. Eq. (7) is the economy's intertemporal Euler equation and we obtain the investment wedge $\frac{1}{1 + \tau_{xt}}$ from it. Finally, the resource constraint (8) allows us to obtain the government consumption wedge.¹

2.2. Computing the wedges

We first compute the steady-state of the economy represented by Eqs. (5)–(8) and we then make a log-linear approximation around this steady state.

We can derive the wedges from the data and from the log-linearized model. The government consumption wedge, \hat{g}_t , is calculated directly from the data, adding up government expenditures and net exports.² Efficiency and labor wedges, A_t and $(1 - \tau_{lt})$,

¹ Although we consider a closed economy, Chari et al. (2007) show that an open economy model with fluctuating borrowing and lending is equivalent to the prototype (closed economy) model considered in this paper with government consumption wedges.

² The rationale for this choice is given by Chari et al. (2005), where the authors set up a standard model of a small open economy in which foreign borrowing is subject to a collateral constraint. They show a rise in net exports in the small open economy corresponds to a rise in government consumption in the prototype model.

respectively, are calculated from the production function (5) and the consumption–leisure relationship (6), respectively. On the other hand, the investment wedge, $\frac{1}{1 + \tau_{xt}}$, must be estimated, as it depends on future expectations according to the Euler Eq. (7).

The estimation procedure follows Chari et al. (2007) and we assume that the stochastic process that governs the state follows an autoregressive vector VAR(1) for the event $s_t = (A_t, \tau_{lt}, \tau_{xt}, g_t)$ of the form:

$$s_{t+1} = P_0 + P s_t + \varepsilon_{t+1}, \quad (9)$$

where P_0 is a vector of constants, P is a matrix of coefficients and ε_t is a white noise shock with covariance matrix $V = QQ'$. So, from the maximum likelihood method, we estimate the parameters of the log-linearized model to obtain the trajectories of the four wedges. More specifically, we want to estimate the following system in state space form:

$$\begin{aligned} X_{t+1} &= A X_t + B \varepsilon_{t+1} \\ Y_t &= C X_t + \omega_t \\ \omega_t &= D \omega_{t-1} + \eta_t, \end{aligned} \quad (10)$$

where A , B , C and D are matrices of coefficients to be estimated, $X_t = [\ln \hat{k}_{t+1}, \ln A_t, \tau_{lt}, \tau_{xt}, \ln \hat{g}_t, 1]'$ and $Y_t = [\ln \hat{y}_t, \ln \hat{x}_t, \ln l_t, \ln \hat{g}_t]$.

The log-likelihood function to be maximized is given by expression (11), where θ is a vector that contains the parameters to be estimated, u_t is an innovation vector and Ω_t its covariance matrix.³

$$L(\theta) = \sum_{t=0}^{T-1} \left\{ \ln |\Omega_t| + \text{tr}(\Omega_t^{-1} u_t u_t') - \ln \left| \frac{\partial f(Z_t, \theta)}{\partial Z_t} \right| \right\} \quad (11)$$

2.3. Data

In order to be able to implement the described methodology, data from the main observable aggregates of the economy is collected. The observables represent income, investment, hours worked, government spending, private consumption and the population of the economy.

In the construction of these series, data from the Gross Domestic Product (GDP), Consumption, Government Spending, Gross Fixed Capital Formation, Exports and Imports of Goods and Services, Taxes on Goods and Services, Employed Population, Adult Population, and Average Hours Worked by Worker were collected. While the Average Hours Worked series was taken from the Penn World Table 10.0, all the other series were taken from the Brazilian Institute of Economics and Statistics (IBGE). Appendix A details the sources used and the treatments performed.

2.4. Calibrated and estimated parameters

Population and technology growth rates, g_n and g_z , respectively, were calculated according to the observed variables used in the model. The parameters related to capital stock depreciation (δ), intertemporal discount factor (β), labor weight in the utility function (ψ), and share of capital in total income (θ) were calibrated according to Graminho (2006). Appendix B details the mentioned calculations and the values used.

Given the calibrated parameters, the parameters P_0 , P and V of the auto-regressive vector VAR(1) of the process that governs the movement of wedges are estimated using the maximum likelihood procedure. For this, the decision rules of the log-linear model are used as well as data on output, consumption, income, investment, government spending and net exports.

3. Results

Having quarterly data from Brazil for the period from 2002 Q1 to 2019 Q4, the calibrated model was used to decompose the economic fluctuations observed in the period. The main results are discussed in the following two subsections: in the first one, the fluctuations observed in the modeled distortions (wedges) are analyzed and related to the Brazilian economy; in the second, the results of the one-wedge economies and the most promising ways to model fluctuations from the 2008 and 2014 recessions in Brazil are presented.

3.1. Wedges

Fig. 1 shows the evolution of efficiency, labor, investment and government wedges. In the case of the latter, its share in the detrended per capita income, \hat{y}_t , is shown. In that sense, we show A_t , $(1 - \tau_{lt})$, $1/(1 + \tau_{xt})$ and \hat{g}_t/\hat{y}_t , respectively, for each wedge. All variables were normalized in relation to their first observation, so that 2002 Q1 = 1.

In Fig. 1, it is possible to observe a worsening of the efficiency wedge in the two periods that coincide with the two most recent economic recessions that hit the Brazilian economy: the 2008 Great Recession and the 2014 recession. Between 2007 Q2 and 2008 Q4, the efficiency wedge declined by 4.0% and, between 2014 Q1 and 2016 Q1, it declined by 10.3%.

³ For detailed derivations, see Kehoe et al. (2006).

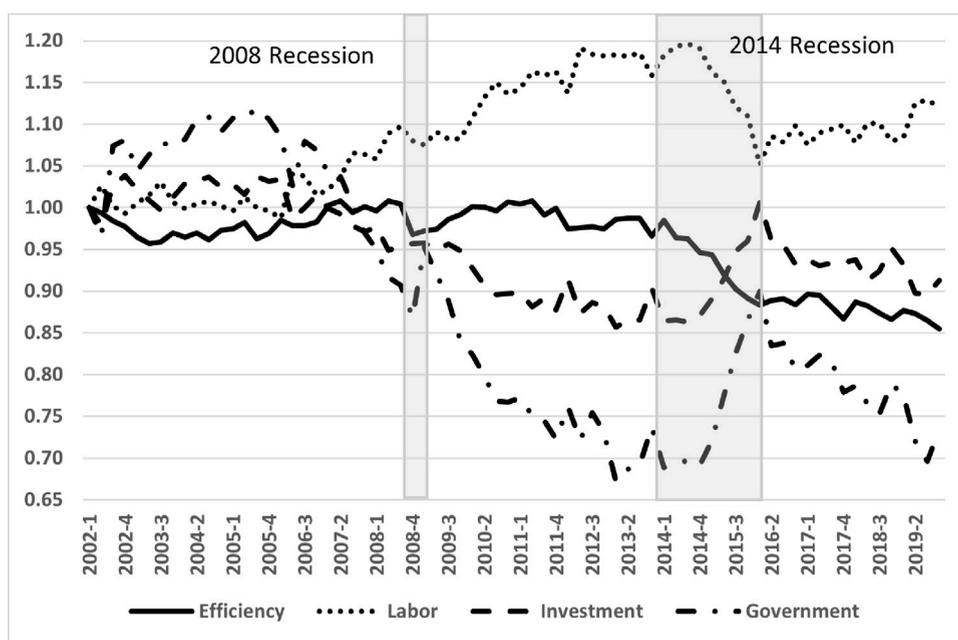


Fig. 1. Wedges in the Brazilian economy 2002:Q1 = 1. Note: Figure shows the evolution of the four wedges (efficiency, labor, investment, and government consumption for Brazil.

Source: Own elaboration.

It is important to highlight that, in addition to the difference in the intensity of the worsening of the efficiency wedge in the two episodes, it is also possible to notice a relevant difference in their behavior after each one of the periods. After the 2008 recession, the efficiency wedge experienced improvements and returned to the 2007 Q2 level in 2010 Q4. The same, however, did not happen in the 2014 crisis. After 2016 Q1, the efficiency wedge kept getting worse until it accumulated a decrease of 13.3% in 2019 Q4 compared to 2014 Q1.

The worsening of the efficiency wedge from 2011 onwards may be correlated with the persistence of countercyclical economic policies introduced as a result of the 2008 recession,⁴ policies which became permanent from the beginning of the 2010s. According to [Spilimbergo and Srinivasan \(2018\)](#), the maintenance of these policies promoted a combination of adversities, such as market distrust, fall in private investment, deterioration of fiscal accounts, high inflation and interest rates, which put Brazil in one of the most severe and lasting recessions in its recent history.

Among these policies, the expansion of earmarked credit through the National Bank for Economic and Social Development (BNDES) stands out. According to [Almeida et al. \(2014\)](#), the development bank was the protagonist of state policies adopted from 2003 with a view to promoting economic growth and, in 2011, it already had more than US\$ 312 billion in assets. By way of contrast, this number is close to the US\$ 338 billion in assets from the World Bank, which operates worldwide.

The authors also point out that the BNDES' incentive structure works in order to prioritize loans to large companies, which are already well established in the market and who have broad access to private capital markets: "the officials from BNDES are partially compensated for the total disbursement of the bank and not for promoting diversification and innovation. Therefore, the bank's incentive structure reinforces the risk minimization bias when lending to large companies in traditional sectors". [Almeida et al. \(2014, p.18\)](#).

Regarding the labor wedge, it is possible to observe a relatively constant increase starting in 2006 Q1. Up to its peak in 2014 Q3, the cumulative increase was 21.2%. Unlike the efficiency wedge, the labor wedge improved in the 2008 recession, increasing 5% between 2007 Q2 and 2008 Q2. In the 2014 crisis, however, there was a drop of 11.1% between 2014 Q1 and 2016 Q1, a period that coincides with the abrupt increase in unemployment, from 6.5% to 12.0%.

Despite the 2008 recession, the labor wedge continued to improve until it reached its highest in 2014 Q3, accumulating an improvement of 15.4% compared to that observed in 2007 Q2. This behavior differs from that observed in the efficiency wedge. Nonetheless, during the 2014 crisis, both showed significant declines. Still, while the efficiency wedge showed no improvement after 2016 Q1, the labor wedge accumulated a positive variation of 6.7% between 2016 Q1 and 2019 Q4.

⁴ The main countercyclical policies adopted by the Brazilian government include expansionist fiscal and monetary policies, tax incentives for durable consumption goods, and use of state-owned banks to boost credit. See [Moreira and Soares \(2012\)](#) for a description and an evaluation of such measures and policies.

Table 1
Peak-through variations and components during the 2008 recession.
Source: Own elaboration.

Variable (X)	Trough	ΔX	ΔX_A	ΔX_L	ΔX_X	ΔX_G
Output	2008 Q4	-4.56	-3.10	-1.69	0.57	-0.34
Hours worked	2009 Q1	-3.87	-3.81	-3.00	0.98	2.04
Investment	2009 Q1	-19.35	-20.63	-6.07	5.01	2.93

Note: The table shows the peak-through variation accounted for each wedge (A , L , X , G) and for each variable (output, hours worked, investment) for the 2008 recession.

The improvement in the labor wedge from 2006 is possibly related to the reduction of unemployment in Brazil. From 9.1% in 2002, the unemployment rate dropped to 6.1% in 2012, a reduction of 32%. In addition, [Barbosa Filho et al. \(2010\)](#) argue that this movement was accompanied by a reduction in the degree of informality in the Brazilian economy, which went from 43.6% in 2002 to 32.5% in 2012.

As shown in [Fig. 1](#), the investment and government wedges decreased during the 2008 recession and increased during the 2014 crisis. While the first accumulated variations of -1.9% between 2017 Q2 and 2008 Q2 and 16.4% between 2014 Q1 and 2016 Q1, the latter showed variations -9.3% and 50.5% during the same periods, respectively.

It is important to note, however, that, unlike the two other wedges, the investment and government wedges have already shown negative oscillations since 2006 Q1, which persisted until the mid-2010s. While the investment wedge deteriorated 13.9% between 2006 Q1 and 2015 Q1, the government wedge reduced 40.3% between 2006 Q1 and 2014 Q1.

The temporal evolution of the wedges is not informative about the relative importance of each one for the business cycle fluctuations observed in the economic variables. We now turn to an evaluation of the significance of each wedge to generate the fluctuations observed during two recession episodes in Brazil.

3.2. 2008 and 2014 recessions

In this subsection, one-wedge economies are introduced, which consist of the reproduction of a given variable with only one of the wedges active, keeping all the others constant and equal to their steady-state values. With this, the objective is to determine the most relevant wedges to explain the fluctuations experienced by the Brazilian economy, in particular those of the 2008 and 2014 crises.

3.2.1. 2008 Great Recession

[Table 1](#) illustrates the peak-trough variations of the variables observed in the 2008 recession, as well as its components. That is, the percentage variation between the largest value of a given variable (peak) and its trough is shown. For this exercise, specifically, the third quarter of 2008 was assumed as the peak for all variables, and the quarter immediately preceding the first positive change observed in the series after the peak is taken as the trough, specified in the second column of [Table 1](#). In addition, the columns ΔX , ΔX_A , ΔX_L , ΔX_X and ΔX_G report the observed X , the counterfactual X in an efficiency wedge economy, the counterfactual X in a labor wedge economy, the counterfactual X in an investment wedge economy and the counterfactual X in a government wedge economy.

The first thing to notice is that, compared to other OECD countries, the impacts of the Great Recession were milder and its duration was shorter in Brazil. [Brinca et al. \(2016\)](#) report an average peak-through output drop of 9.9% with an average length of 2.3 years for 24 OECD countries. In Brazil, by contrast, the peak-through output drop was 4.6% with the recession lasting for one quarter.

It is possible to notice that the efficiency wedge maps the most relevant distortions to explain the fluctuations in output, hours worked, and investment observed in the 2008 recession. For the analyzed period, the economy with only the efficiency wedge was able to reproduce approximately 68% of the drop in output, in addition to producing practically the whole fluctuations in hours worked and in investment. The prominence of the efficiency wedge to explain output fluctuations during the Great Recession was also found by [Brinca et al. \(2016\)](#) for the OECD countries except for the United States, Spain, Ireland, Iceland, and New Zealand.

In the secondary level, the economy with only the labor wedge also performed well in reproducing fluctuations in output and worked hours, but was unable to replicate the fall in investment. Economies with only investment and government wedges did not show satisfactory results and produced fluctuations in the opposite direction to those present in the observed variables.

In addition to the peak-through variation, the ϕ statistics was also computed, which is commonly reported in BCA studies to capture the correlation between a variable and its components computed from the one-wedge exercises. Eq. (12) describes the correlation ϕ between a variable Y and one of its components, i , with $i = \{A, \tau_l, \tau_x, g\}$.

$$\phi_i^Y = \frac{1 / \sum_t (y_t - y_{it})^2}{\sum_j (1 / \sum_t (y_t - y_{jt})^2)} \quad (12)$$

As argued by [Brinca et al. \(2016\)](#), the use of the ϕ statistics for BCA is desirable because: (1) its domain belongs to the $[0, 1]$ interval, making interpretation simple; (2) when a wedge i perfectly explains the fluctuations of a variable (i.e., $y_t - y_{it} = 0 \forall t$), then

Table 2 ϕ statistics for the components of the observed variables: 2008 recession.

Source: Own elaboration.

ϕ_A^Y	$\phi_{\tau_L}^Y$	$\phi_{\tau_x}^Y$	ϕ_g^Y	ϕ_A^L	$\phi_{\tau_L}^L$	$\phi_{\tau_x}^L$	ϕ_g^L	ϕ_A^x	$\phi_{\tau_L}^x$	$\phi_{\tau_x}^x$	ϕ_g^x
0.67	0.20	0.07	0.06	0.17	0.74	0.05	0.04	0.67	0.19	0.07	0.07

Note: The table shows the ϕ statistics for each wedge (A , τ_L , τ_x , g) and for each variable (output, hours worked, investment) for the 2008 recession.**Table 3**

Peak-through variations and components: 2014 crisis.

Source: Own elaboration.

Variable (X)	Trough	ΔX	ΔX_A	ΔX_L	ΔX_X	ΔX_G
Product	2016 Q1	-16.48	-19.84	-12.14	10.00	6.30
Hours worked	2017 Q1	-8.17	-7.53	-13.38	3.10	6.48
Investment	2017 Q2	-40.69	-50.01	-17.10	2.30	17.07

Note: The table shows the peak-through variation accounted for each wedge (A , L , X , G) and for each variable (output, hours worked, investment) for the 2014 recession.

$\phi_i^Y = 1$; and 3) because it is the inverse of the sum of squares of the residuals for each of the normalized wedges, with the sum of all the wedges being such that $\sum_i \phi_i^Y = 1$.

Table 2 shows the ϕ statistics for the components of output, hours worked, and investment for the period 2008 Q3 to 2009 Q3.⁵ It is noteworthy that the results confirm the peak-trough analysis for product and investment fluctuations, the efficiency wedge being the most decisive component to explain them, followed by the labor wedge. On the other hand, the ϕ statistics of the components of hours worked suggest that the labor wedge is best suited to explain the observed fluctuations, followed by the efficiency wedge.

Figs. C.1–C.3 in Appendix C contrast, respectively, output, hours worked and investment with their components. The values were normalized so that 2008 Q2 = 1 and confirm the points discussed so far. As mentioned in the peak-trough analysis, the efficiency wedge is, in fact, a more determining factor in reproducing the fluctuations experienced by the observed variables, being able to predict almost perfectly all the falls caused by the 2008 recession.

In addition, Fig. C.2 justifies the low ϕ statistic for the efficiency component wedge of hours worked. It is possible to notice that, although the efficiency wedge economy reproduces the decline observed between 2008 Q2 and 2009 Q1, it overestimates the recovery of this variable from 2009 Q2, which does not happen in the labor wedge economy.

Finally, Figs. D.1–D.3 in Appendix D illustrate the exercise of contrasting the variables observed with a prototype economy that contains all but one wedges. For example, the no efficiency wedge economy reproduces the observed variables “turning off” the efficiency wedge. The results also confirm that investment and government wedges are the least relevant distortions in the reproduction of observed fluctuations.

Therefore, the exercises performed seem to suggest that models that incorporate distortions related to the efficiency and employment level of the economy are the most promising to explain the fluctuations experienced by output, hours worked and investment during the 2008 recession in Brazil.

3.2.2. 2014 crisis

Similar to what was done in the previous subsection, Table 3 summarizes the results of the peak-trough analysis for the period of the 2014 crisis. Again, the highest product observed immediately before the start of the crisis (2014 Q1) was chosen as the peak and the quarter representing the observation immediately preceding the first positive variation of the series was the trough. For each of the observed variables, the trough column details the chosen period.

The first point to draw attention is the longer duration of the decline period in all observed variables. While the resumption of output growth took a quarter to happen in the 2008 recession, in the 2014 episode the beginning of the recovery started only two years later, as can be seen in the ‘trough’ column of Table 3. For hours worked and investment, two quarters were needed for recovery in the 2008 recession, compared to three years and a quarter in the 2014 recession.

In addition to the longer duration, Table 3 also shows the greater severity of the episode, with the drop observed for the product being more than three times greater than that observed in the economy in 2008. Moreover, changes in hours worked and investment represent more than twice those seen in the previous episode for these variables.

From the fluctuations mentioned above, we can see that the efficiency wedge was again able to reproduce them with greater accuracy, producing variations of -19.8%, -8.2% and -50.0% for product, hours worked and investment, compared to observed variations of -16.5%, -8.2% and -40.7%, respectively.

Similar to the 2008 episode, the labor wedge was the second component that best explained the fluctuations of the 2014 crisis, reproducing about 73% of the fall in the product and 42% of the fall in investment. In addition, similar to what was observed in the exercise for the 2008 period, the investment wedge and government wedge economies produced fluctuations in the opposite direction of those experienced by the observed variables.

⁵ Different from the peak-trough analysis, the ϕ statistic was computed including the post-crisis recovery period, following Brinca et al. (2016).

Table 4 ϕ statistics for components of the observed variables: 2014 crisis.

Source: Own elaboration.

ϕ_A^Y	$\phi_{\tau_L}^Y$	$\phi_{\tau_x}^Y$	ϕ_g^Y	ϕ_A^L	$\phi_{\tau_L}^L$	$\phi_{\tau_x}^L$	ϕ_g^L	ϕ_A^x	$\phi_{\tau_L}^x$	$\phi_{\tau_x}^x$	ϕ_g^x
0.79	0.16	0.02	0.03	0.49	0.26	0.11	0.15	0.37	0.49	0.03	0.11

Note: The table shows the ϕ statistics for each wedge (A , τ_L , τ_x , g) and for each variable (output, hours worked, investment) for the 2014 recession.

Additionally, [Table 4](#) repeats the ϕ statistics calculation exercise for 2014. More specifically, we choose to contemplate the period between 2014 Q1 and 2016 Q1. In relation to the fluctuations in the product, the results confirm the peak-trough analysis, and point out that the efficiency wedge component was responsible for 79% of the fluctuations experienced by the observed variable, and the labor wedge, accounts for 16%. Once again, the investment and government wedges were not relevant.

In addition, the efficiency wedge component was also able to reproduce 49% of fluctuations observed in hours worked, followed by the labor wedge, with 26%. For investment, however, the labor wedge was the most important component, being responsible for 49% of the movements observed in the period, followed by the efficiency wedge, with 37%.

[Brinca and Costa-Filho \(2022\)](#) also found that the efficiency wedge is the main driver of the output drop during the 2014 recession, but they report that 98% of output fluctuation is due to the efficiency wedge leaving no role to the other wedges.

The greater relevance of the efficiency wedge to explain the 2014 fluctuations is also reflected in the one wedge off economies. [Figs. D.4–D.6 in Appendix D](#) show that the no-inefficiency wedge is unable to keep up with the trend of the product, hours worked, and investment. On the other hand, the withdrawal of the government wedge does not seem to significantly impact the reproduction of the observed variables, corroborating with the conclusions obtained from the peak-trough and ϕ analyses.

It is important to highlight the greater relevance of the efficiency wedge and the opposite movement by the labor wedge. The loss of relevance of the labor wedge to explain the economic fluctuations experienced by output during the 2014 crisis stands in opposition to what was found by [Manfredini \(2020\)](#) and may be related to the use of historical series or different treatments for the hours worked data.

It is relevant to emphasize, additionally, the inversion between the components of the efficiency and labor wedges as the main factor capable of reproducing hours worked and investment for both episodes. While in the first episode, the labor wedge proved to be the most relevant to explain fluctuations in hours worked, in the second episode the efficiency wedge became more important. The opposite can be seen for investment.

In the BCA framework, therefore, the evidence presented suggests that the recession episodes that the Brazilian economy went through as of 2014 can be characterized as a recession related to productivity fluctuations. In that regard, models that map distortions linked to efficiency and the labor market should be more promising than those associated to investment-related distortions and to government spending.

Some promising models of detailed economies mapping different frictions as efficiency or labor wedges have been presented in the literature. [Chari et al. \(2007\)](#) consider a detailed economy with input-financing frictions that capture the idea that some firms, such as small firms, may be financially constrained. The authors show that such a detailed economy is equivalent to the prototype growth economy of this paper with efficiency, labor, and investment wedges. [Chari et al. \(2007\)](#) also develop a model of a detailed monetary economy with sticky wages like that of [Bordo et al. \(2000\)](#) and show the equivalence of such a model with a (real) prototype growth economy with labor wedges. Another interesting equivalence result is provided by [Neumeyer and Perri \(2005\)](#) which, in an open-economy environment, showed that in a model in which firms face a working capital constraint variations in the interest rate show up as changes in the labor wedge. [Brinca and Costa-Filho \(2022\)](#) survey the literature on equivalence results between detailed economies with frictions and prototype economies with wedges.

Another promising line of research is to evaluate different competing models and possible explanations for the business cycle fluctuations of the labor wedge. [Gali et al. \(2007\)](#) decompose the labor wedge into a firm-based gap and a household-based gap and interpret the former as a price markup and the latter as a wage markup to measure the welfare costs of business cycles in the United States. [Karabarbounis \(2014\)](#) performs a similar exercise for the United States decomposing the labor wedge into a gap between the measured marginal product of labor (MPN) and the real wage (the firm component) and a gap between the real wage and the measured marginal rate of substitution between leisure and consumption (MRS) (the household component). [Fasolo et al. \(2023\)](#) develop a DSGE model for Brazil and show historical shock decomposition for the unemployment rate with labor market shocks dominated by wage markup shocks rather than labor supply shocks.

Another influential contribution is [Shimer \(2009\)](#) which evaluates the possible contribution of different explanations to account for the labor wedge fluctuations over the business cycles. In particular, [Shimer \(2009\)](#) addresses the role played by tax changes, model misspecification, shocks to the household's disutility of labor, changes in the workers' wage-setting power, and search frictions combined with real wage rigidities.

The prominence of efficiency wedges in the 2008 and 2014 recessions are in line with the evidence from other historical periods ([Graminho, 2006](#); [Lama, 2011](#); [Chakraborty and Otsu, 2013](#)) and also with the evidence showing the significance of productivity shocks for output fluctuations in the class of RBC models ([Ellery Jr. et al., 2002](#); [Araujo, 2012](#)), the importance of TFP in growth-accounting exercises ([Bugarin et al., 2007](#)), and the relevance of supply shocks in historical shock decomposition exercises for output during the 2014 recession ([Fasolo et al., 2023](#)).

4. Final considerations

After a decade of economic performance above its peers, Brazil experienced adverse conditions from 2014 onwards, which led to a significant deterioration in the macroeconomic environment and culminated in one of the worst recessions in its history. In order to study these economic fluctuations, the present paper used quarterly data from 2002 to 2019 to model the distortions present in the Brazilian economy during this period in light of the methodology developed by [Chari et al. \(2007\)](#).

As shown in Section 3.1, the efficiency wedge improved between 2003 Q2 and 2008 Q2, before falling 4% due to the 2008 recession. In the 2014 crisis, on the other hand, it deteriorated in a more relevant way until accumulating a drop of 13.3% in 2019 Q4, compared to 2014 Q1. The labor wedge improved practically continuously until the beginning of 2015, reversing its course afterward and experiencing a negative variation of 11.1% between 2014 Q1 and 2016 Q1, which coincides with the increase in unemployment due to the 2014 crisis.

When the recessive episodes of 2008 and 2014 are contrasted, we found that the 2014 crisis was relatively more severe and longer lasting than the 2008 recession. The peak-trough variation shows that output, hours worked and investment changed negatively by 4.6%, 3.9% and 19.4% during the 2008 recession, respectively. For the 2014 crisis, the variations were -16.5%, -8.2% and -40.7% for an average period of 11 quarters, respectively.

In addition, simulations were performed for the variables observed through the individual and joint introduction of wedges in the model. The results of this exercise suggest that, for both recession episodes, the efficiency wedge best explained the fluctuations analyzed, followed by the labor wedge. In that regard, models that map distortions related to productivity and the labor market should perform better when contrasted with the data.

In conclusion, we see this study as offering a diagnosis related to the most relevant wedges driving two recent recession episodes in Brazil and, in this way, to help narrow the focus of the most promising lines of research investigation related to this subject.

CRedit authorship contribution statement

Matheus Cardoso Leal: Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation.
Márcio Issao Nakane: Writing – review & editing, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Data

In order to use the proposed methodology, data from the following macroeconomic aggregates are required: Gross Domestic Product, Consumption, Government Spending, Investment, Exports and Imports. All of them were obtained from the Brazilian Institute of Geography and Statistics (IBGE). The series at 1995 prices were used with seasonally adjusted, quarterly frequency, between 2002 Q1 and 2019 Q4. Furthermore, the ratio between taxes on goods and GDP at market prices was used to deduct the tax component from income and private consumption. [Table A.1](#) summarizes the sources mentioned, as well as the treatments given to each variable.

Due to the unavailability of good data on hours worked in Brazil, we decided to construct a series based on data from the Average Annual Hours Worked by Persons Engaged (AVH) from *Penn World Tables 10.0* and Occupied Population data from IBGE. To change the frequency of the AVH series to the quarterly frequency, we linearly interpolated and divided the result by four.

In addition, the *Pesquisa Mensal de Emprego* (PME) survey from IBGE was interrupted in March 2016, with the release of data referring to the month of February 2016. *Pesquisa Mensal por Amostra de Domicílios Contínua* (PNAD-C) survey replaced the old PME, broadening the coverage to the entire country, in contrast to the PME, which only covered the Metropolitan Regions of Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo and Porto Alegre, which makes the two methodologies not comparable to each other.

Thus, we chose to reproject the PNAD-C data using the rates of change for PME. This procedure was used for the Occupied Population series, used in combination with AVH to create the series of hours worked, and in the series of Labor Force (PIA), used in the construction of the per capita variables. [Table A.2](#) summarizes the procedure.

In addition, the construction of the per capita series was carried out by dividing the macroeconomic aggregates by the number of workers in the economy, as measured by the PIA. Furthermore, the series of hours worked was divided by the constant value

Table A.1

Macroeconomic aggregates.

Source: Own elaboration.

Notation	Description	Unit	Frequency	Source	Period
\tilde{Y}_t	Gross domestic product	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
\tilde{C}_t	Consumption	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
\tilde{G}_t	Government spending	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
I_t	Fixed capital gross formation	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
X_t	Exports	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
M_t	Imports	10 ⁶ R\$ of 1995 SA	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
T_t	Taxes	10 ⁶ R\$	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
$Y_{pm,t}$	Gross domestic product	10 ⁶ R\$	Quarterly	IBGE - CNT	2002 T1 – 2019 T4
t_t	$T_t/Y_{pm,t}$	–	Quarterly	–	2002 T1 – 2019 T4
\tilde{G}_t	$\tilde{G}_t + X_t - M_t$	–	Quarterly	–	2002 T1 – 2019 T4
Y_t	$\tilde{Y}_t(1 - t_t)$	–	Quarterly	–	2002 T1 – 2019 T4
C_t	$\tilde{C}_t(1 - t_t)$	–	Quarterly	–	2002 T1 – 2019 T4

Note: Table shows the macroeconomic variables used in the study, their unit of measure, frequency, source, and period.

Table A.2

Hours worked series.

Source: Own elaboration.

Notation	Description	Unit	Frequency	Source	Period
AVWH _g	Average annual hours worked by persons engaged	Hours	Annual	<i>Penn World Tables 10.0</i>	2002–2019
PO _{PME,t}	Occupied population (PME)	Thousands	Quarterly	IBGE - PME	2002 T1 – 2015 T4
PO _{PNAD-C,t}	Occupied population (PNAD-C)	Thousands	Quarterly	IBGE - PNAD-C	2012 T1 – 2020 T4
AVWH _t	Linear interpolation (AVWH _g)/4	–	Quarterly	–	2002 T1 – 2020 T4
\tilde{PO}_t	PO _{PNAD-C,t+1} * (PO _{PME,t} /PO _{PME,t+1}), if $t \leq 2011$ T4	–	Quarterly	–	2002 T1 – 2011 T4
\widehat{PO}_t	PO _{PNAD-C,t} , if $t \geq 2012$ T1	–	Quarterly	–	2012 T1 – 2020 T4
PO _t	$\tilde{PO}_t \cup \widehat{PO}_t$	–	Quarterly	–	2002 T1 – 2020 T4
H _t	AVWH _t * PO _t	–	Quarterly	–	2002 T1 – 2020 T4

Note: Table shows the variables used for the hours worked series and for the population size series. The top shows the original series, their unit of measure, frequency, source, and period. The bottom shows the transformations made from the original series.

Table A.3

Per capita series.

Source: Own elaboration.

Notation	Description	Unit	Frequency	Source	Period
PIA _{PME,t}	Labor force (PME)	Thousands	Quarterly	IBGE - PME	2002 T1 – 2015 T4
PIA _{PNAD-C,t}	Labor force (PNAD-C)	Thousands	Quarterly	IBGE - PNAD-C	2012 T1 – 2020 T4
\widehat{PIA}_t	PIA _{PNAD-C,t+1} * (PIA _{PME,t} /PIA _{PME,t+1}), if $t \leq 2011$ T4	–	Quarterly	–	2002 T1 – 2011 T4
\widehat{PIA}_t	PIA _{PNAD-C,t} , if $t \geq 2012$ T1	–	Quarterly	–	2012 T1 – 2020 T4
PIA _t	$\widehat{PIA}_t \cup \widehat{PIA}_t$	–	Quarterly	–	2002 T1 – 2020 T4
ypc _t	Y _t /PIA _t	–	Quarterly	–	2002 T1 – 2019 T4
cpc _t	C _t /PIA _t	–	Quarterly	–	2002 T1 – 2019 T4
ipc _t	I _t /PIA _t	–	Quarterly	–	2002 T1 – 2019 T4
gpc _t	G _t /PIA _t	–	Quarterly	–	2002 T1 – 2019 T4
hpc _t	H _t /PIA _t /1250	–	Quarterly	–	2002 T1 – 2019 T4

Note: Table shows the variables used for the computation of per capita series (top) and the transformations made in the series (bottom).

1250, which represents the labor endowment. This procedure is standard in the literature and we chose to follow the procedure used by [Simonovska and Söderling \(2015\)](#) (see [Table A.3](#)).

Some (if not most) of the differences in the results of our paper and other BCA studies for Brazil are due to differences in the variables related to the labor market. [Lama \(2011\)](#) uses PME for employment and World Bank World Development Indicators (WDI) for working age population (age 15 and above). [Chakraborty and Otsu \(2013\)](#) use hours worked per worker from the Euromonitor Global Market Information Database, employment and population from Penn World Tables 7.0, and adult share in total population from the International Labour Office (ILO) LABORSTA database. [Manfredini \(2020\)](#) calculates the average share of hours worked by the population between 15–64 from the International Labour Office (ILO) LABORSTA database and the working-age population (15–64) from the World Bank World Development Indicators (WDI). [Brinca and Costa-Filho \(2022\)](#) use the same AVH series from PWT 10.0 for hours worked that we used but, unlike us, use the working age population (15–64) from OECD. [Table A.4](#) summarizes the labor market variables used in these other studies.

Finally, [Table A.5](#) depicts the series used in the modeling, and [Figs. A.1\(a\)–A.1\(d\)](#) present them graphically.

Table A.4
Labor market variables from other studies.
Source: Own elaboration.

Reference	Series	Source
Lama (2011)	Employment	PME
	Working age population (15–64)	WDI
Chakraborty and Otsu (2013)	Hours worked per worker	EM
	Employment, population	PWT 7.0
	Adult share in total population	ILO
Manfredini (2020)	Hours worked by population 15–64	ILO
	Working age population (15–64)	WDI
Brinca and Costa-Filho (2022)	Hours worked by person engaged	PWT 10.0
	Working age population (15–64)	OECD

Note: Table shows the treatment of labor market variables from other BCA studies for Brazil. PME stands for *Pesquisa Nacional de Emprego* from IBGE; EM stands for Euromonitor Global Market Information Database; ILO stands for International Labour Office LABORSTA database; WDI stands for World Bank World Development Indicators; PWT stands for Penn World Tables.

Table A.5
Series in Ln.
Source: Own elaboration.

Notation	Description	Frequency	Period
y_t	$\ln y_{pc,t}$	Quarterly	2002 T1 – 2019 T4
c_t	$\ln c_{pc,t}$	Quarterly	2002 T1 – 2019 T4
i_t	$\ln ipc_t$	Quarterly	2002 T1 – 2019 T4
g_t	$\ln gpc_t$	Quarterly	2002 T1 – 2019 T4
h_t	$\ln hpc_t$	Quarterly	2002 T1 – 2019 T4

Note: Table shows the per capita series used in the model, their frequency, and period.

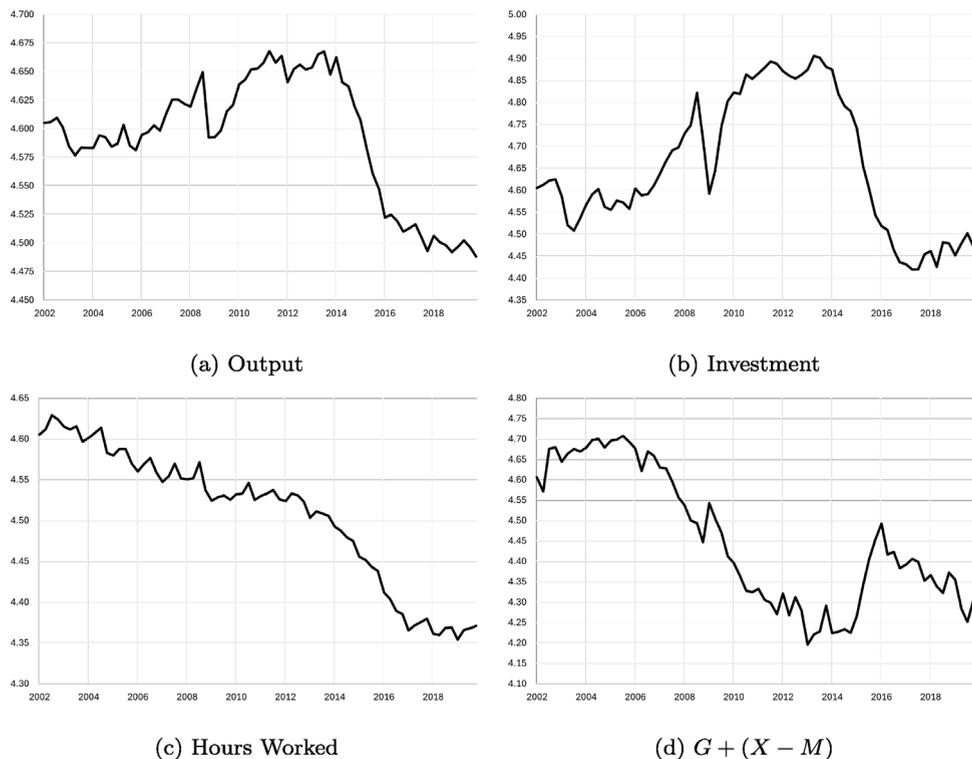


Fig. A.1. Natural logarithm of per capita variables. Note: Figure (a) shows the natural log of per capita output; Figure (b) shows the natural log of per capita investment; Figure (c) shows the natural log of hours worked; Figure (d) shows the natural log of the sum of per capita government spending and per capita net exports.

Source: Own elaboration.

Table B.1

Calibrated parameters.

Source: Own elaboration.

Variable	Description	Reference	Annual	Quarterly
g_n	Population growth	Calculated	1.49%	0.37%
g_z	Technology growth	Calculated	1.52%	0.38%
δ	Capital depreciation	Graminho (2006)	4.06%	1.03%
β	Intertemporal discount	Graminho (2006)	97.42%	99.35%
ψ	Labor parameter	Graminho (2006)	2.18	2.18
θ	Capital share on income	Graminho (2006)	0.33%	0.33%

Note: Table shows the calibrated parameters used in the model simulation.

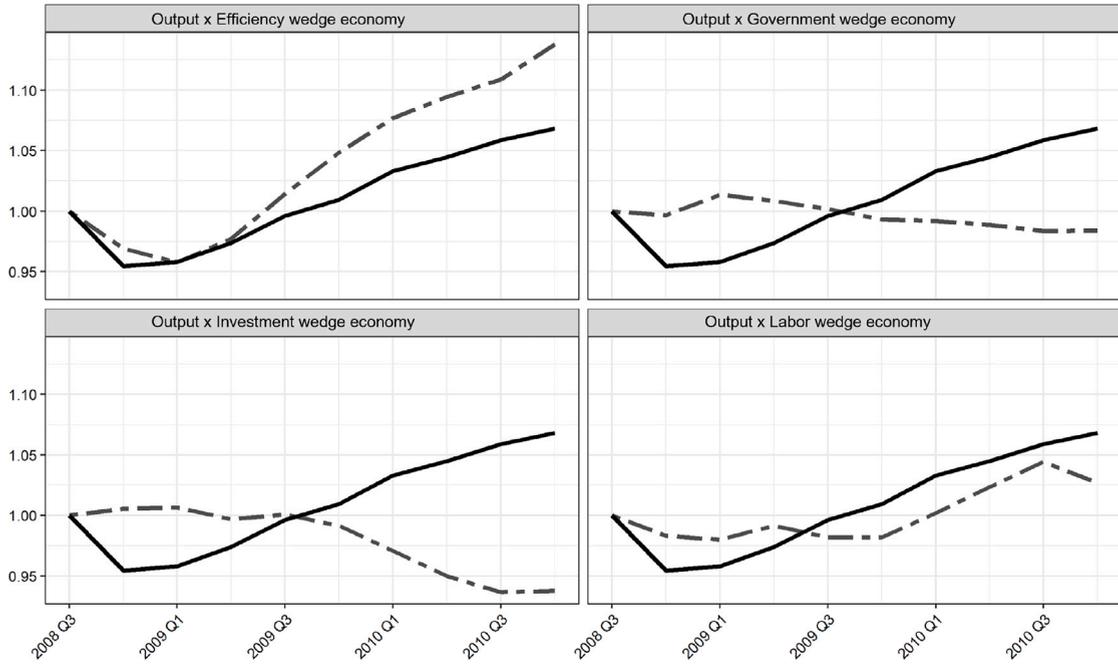


Fig. C.1. 2008 recession: Output and one wedge economies. Figure shows observed output and its counterfactual during 2008 Recession if only one wedge is active. Up and left: Counterfactual output if only efficiency wedge is active. Up and right: Counterfactual output if only government wedge is active; Bottom and left: Counterfactual output if only investment wedge is active; Bottom and right: Counterfactual output if only labor wedge is active.

Source: Own elaboration.

Appendix B. Parameters

Based on the Labor Force, the population growth was calculated as:

$$g_n = \left(\frac{PIA_{2019T4}}{PIA_{2002T1}} \right)^{1/71} - 1 \tag{B.1}$$

To calculate the growth of the technology, we found g_z so that the mean of the natural logarithm of output per capita is zero over the sample period. That is we find g_z to solve:

$$\sum_{t=0}^{T-1} \ln \left[\frac{YPC_t}{(1 + g_z)^t} \right] = 0 \tag{B.2}$$

The remaining parameters were calibrated according to what is usual in the literature, and are summarized in [Table B.1](#).

Appendix C. One wedge economies

See [Figs. C.1–C.6](#).

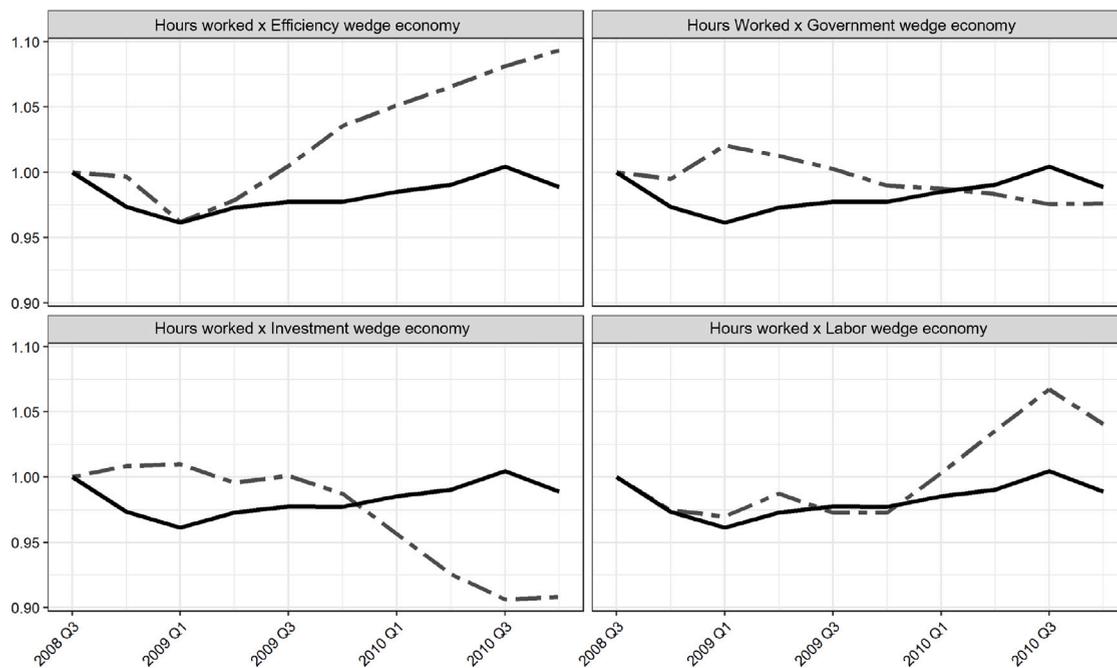


Fig. C.2. 2008 recession: Hours worked and one wedge economies. Figure shows observed hours worked and its counterfactual during 2008 Recession if only one wedge is active. Up and left: Counterfactual hours worked if only efficiency wedge is active. Up and right: Counterfactual hours worked if only government wedge is active; Bottom and left: Counterfactual hours worked if only investment wedge is active; Bottom and right: Counterfactual hours worked if only labor wedge is active. Source: Own elaboration.

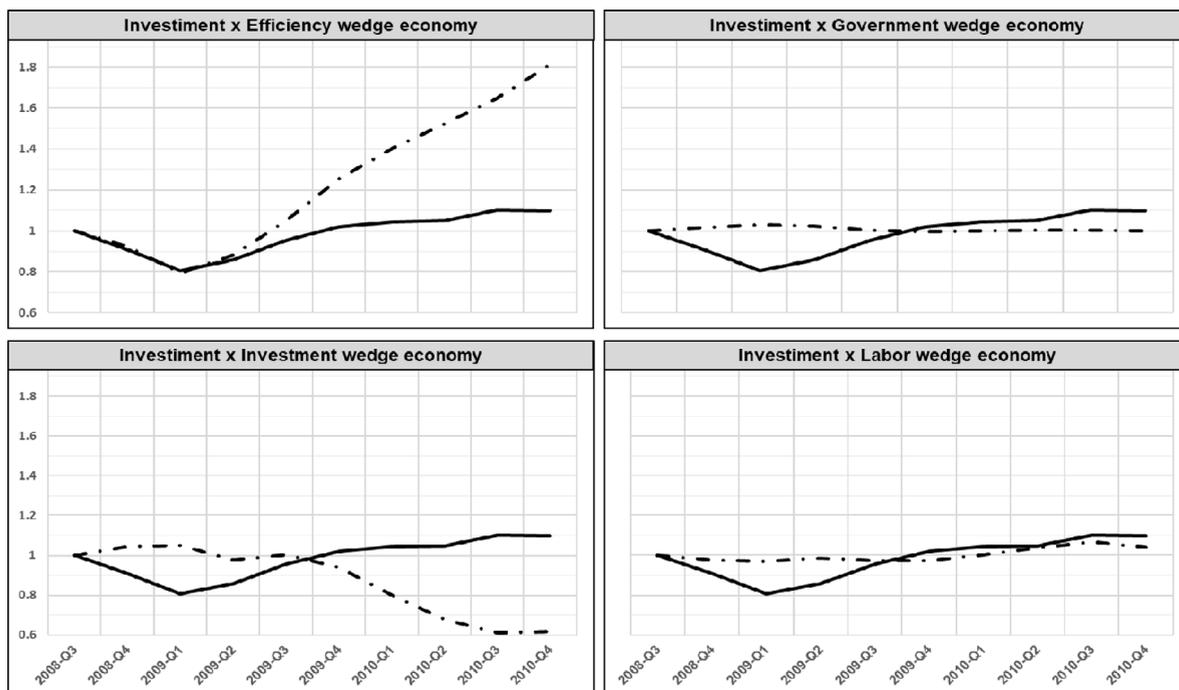


Fig. C.3. 2008 recession: Investment and one wedge economies. Figure shows observed investment and its counterfactual during 2008 Recession if only one wedge is active. Up and left: Counterfactual investment if only efficiency wedge is active. Up and right: Counterfactual investment if only government wedge is active; Bottom and left: Counterfactual investment if only investment wedge is active; Bottom and right: Counterfactual investment if only labor wedge is active. Source: Own elaboration.

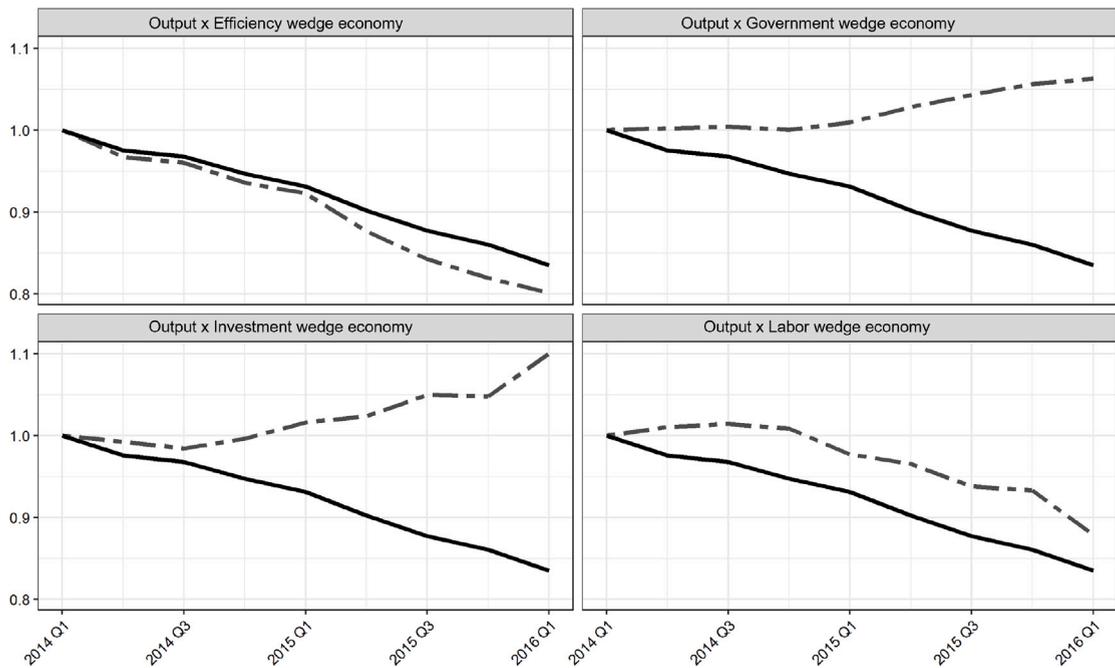


Fig. C.4. 2014 crisis: Output and one wedge economies. Figure shows observed output and its counterfactual during 2014 Recession if only one wedge is active. Up and left: Counterfactual output if only efficiency wedge is active. Up and right: Counterfactual output if only government wedge is active; Bottom and left: Counterfactual output if only investment wedge is active; Bottom and right: Counterfactual output if only labor wedge is active. Source: Own elaboration.

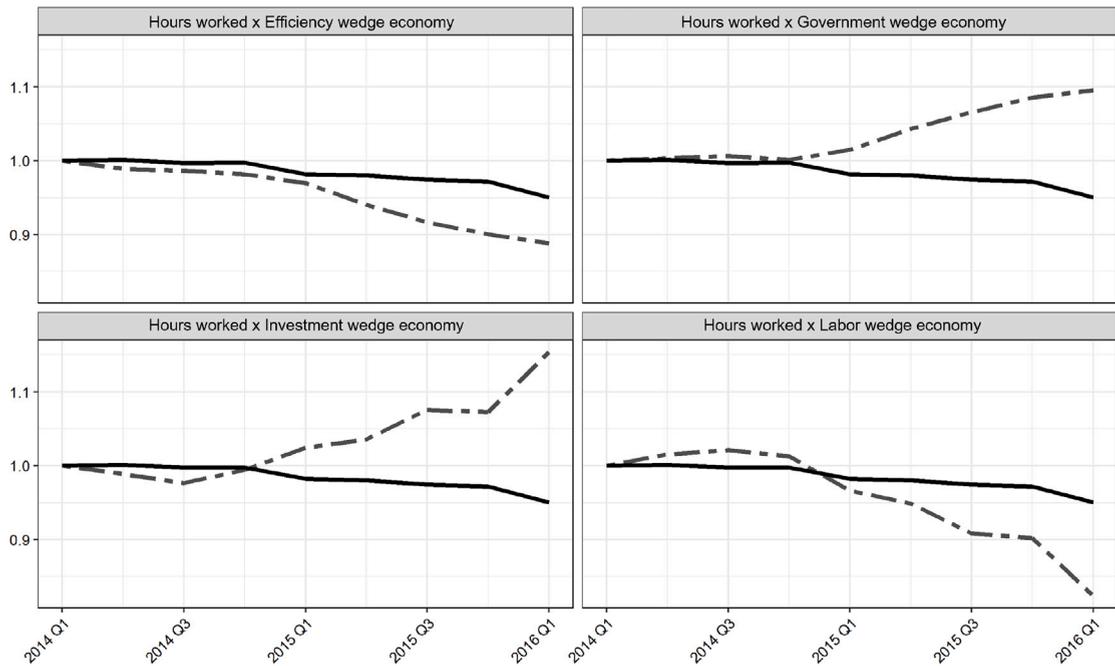


Fig. C.5. 2014 crisis: Hours worked and one wedge economies. Figure shows observed hours worked and its counterfactual during 2014 Recession if only one wedge is active. Up and left: Counterfactual hours worked if only efficiency wedge is active. Up and right: Counterfactual hours worked if only government wedge is active; Bottom and left: Counterfactual hours worked if only investment wedge is active; Bottom and right: Counterfactual hours worked if only labor wedge is active. Source: Own elaboration.

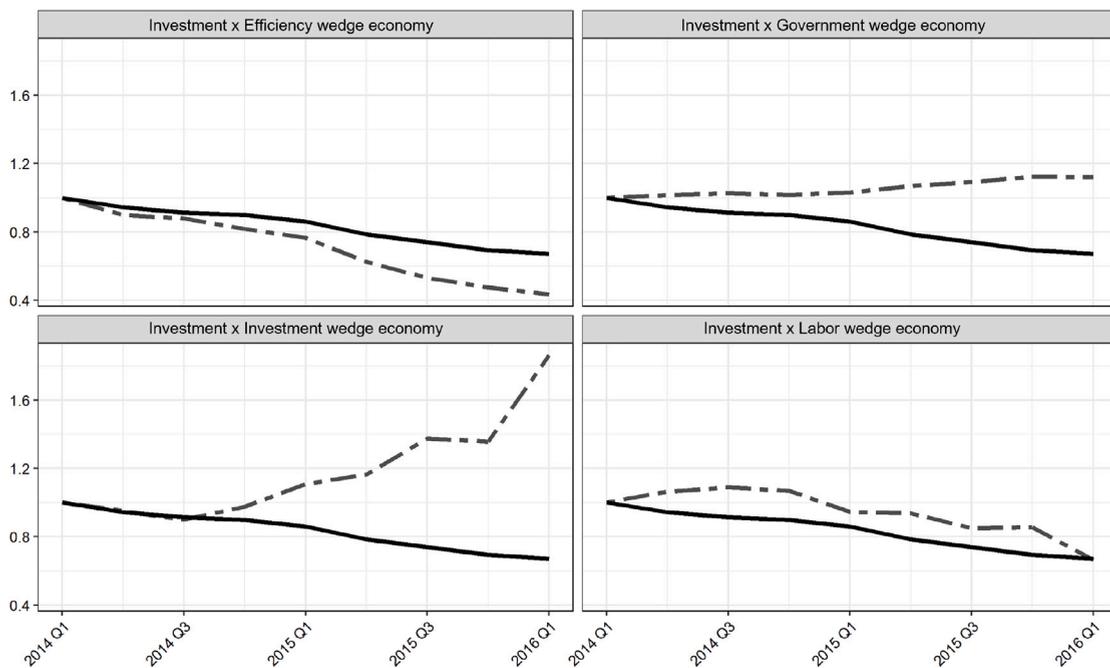


Fig. C.6. 2014 crisis: Investment and one wedge economies. Figure shows observed investment and its counterfactual during 2014 Recession if only one wedge is active. Up and left: Counterfactual investment if only efficiency wedge is active. Up and right: Counterfactual investment if only government wedge is active; Bottom and left: Counterfactual investment if only investment wedge is active; Bottom and right: Counterfactual investment if only labor wedge is active. Source: Own elaboration.

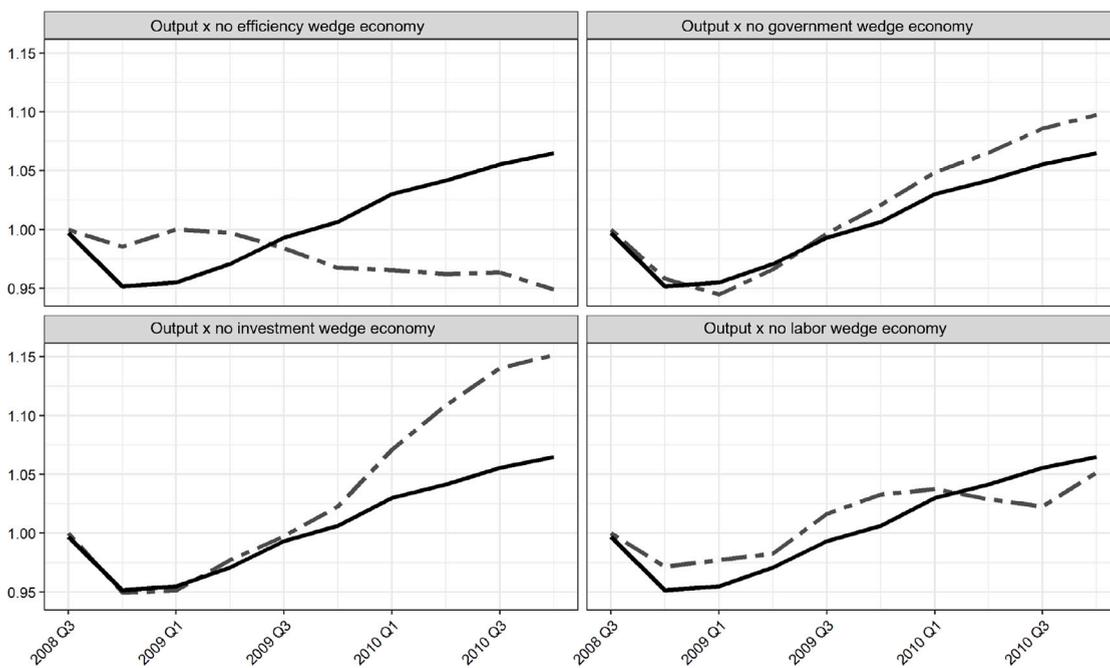


Fig. D.1. 2008 recession: Output and one wedge off economies. Figure shows observed output and its counterfactual during 2008 Recession if only one wedge is not active. Up and left: Counterfactual output if only efficiency wedge is not active. Up and right: Counterfactual output if only government wedge is not active; Bottom and left: Counterfactual output if only investment wedge is not active; Bottom and right: Counterfactual output if only labor wedge is not active. Source: Own elaboration.

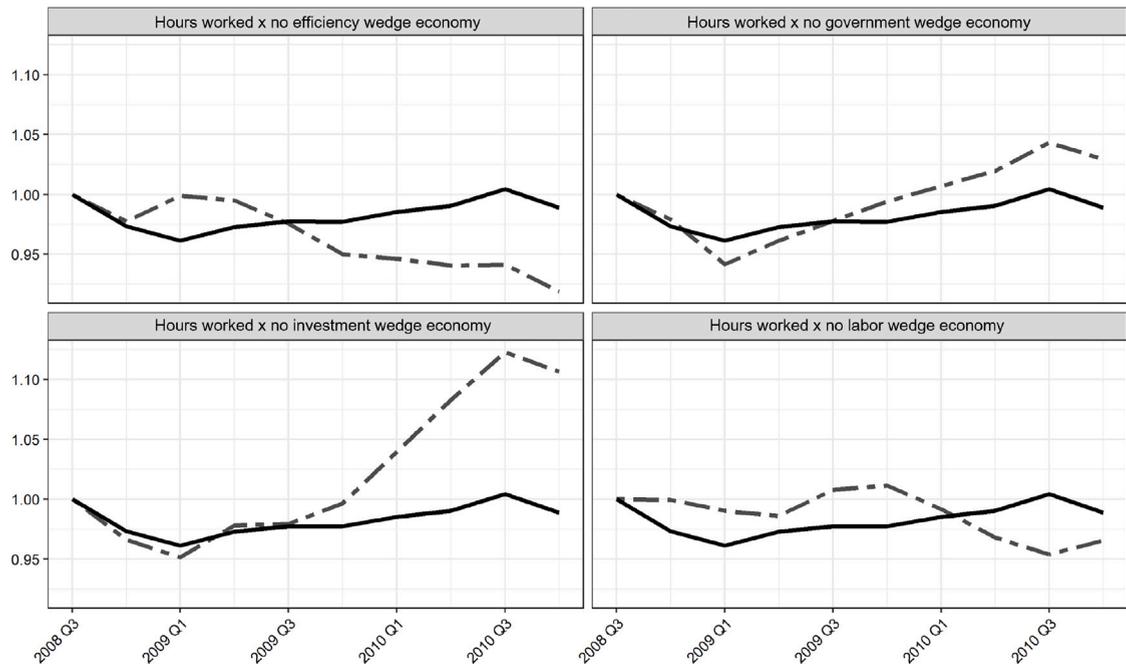


Fig. D.2. 2008 recession: Hours worked and one wedge off economies. Figure shows observed hours worked and its counterfactual during 2008 Recession if only one wedge is not active. Up and left: Counterfactual hours worked if only efficiency wedge is not active. Up and right: Counterfactual hours worked if only government wedge is not active; Bottom and left: Counterfactual hours worked if only investment wedge is not active; Bottom and right: Counterfactual hours worked if only labor wedge is not active.
 Source: Own elaboration.

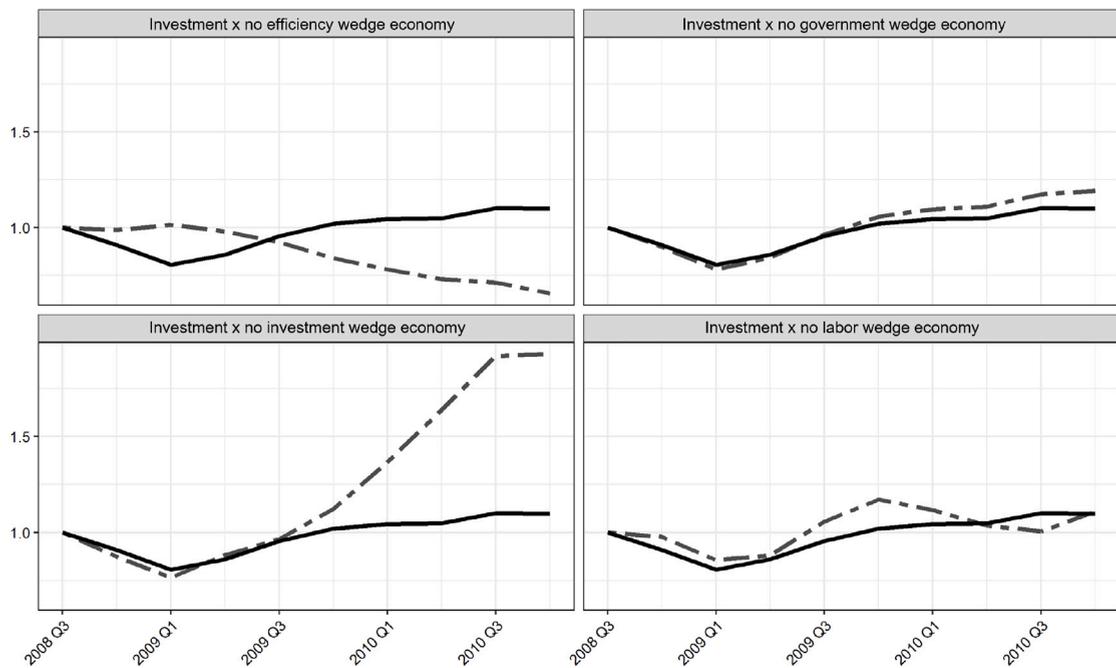


Fig. D.3. 2008 recession: Investment and one wedge off economies. Figure shows observed investment and its counterfactual during 2008 Recession if only one wedge is not active. Up and left: Counterfactual investment if only efficiency wedge is not active. Up and right: Counterfactual investment if only government wedge is not active; Bottom and left: Counterfactual investment if only investment wedge is not active; Bottom and right: Counterfactual investment if only labor wedge is not active.
 Source: Own elaboration.

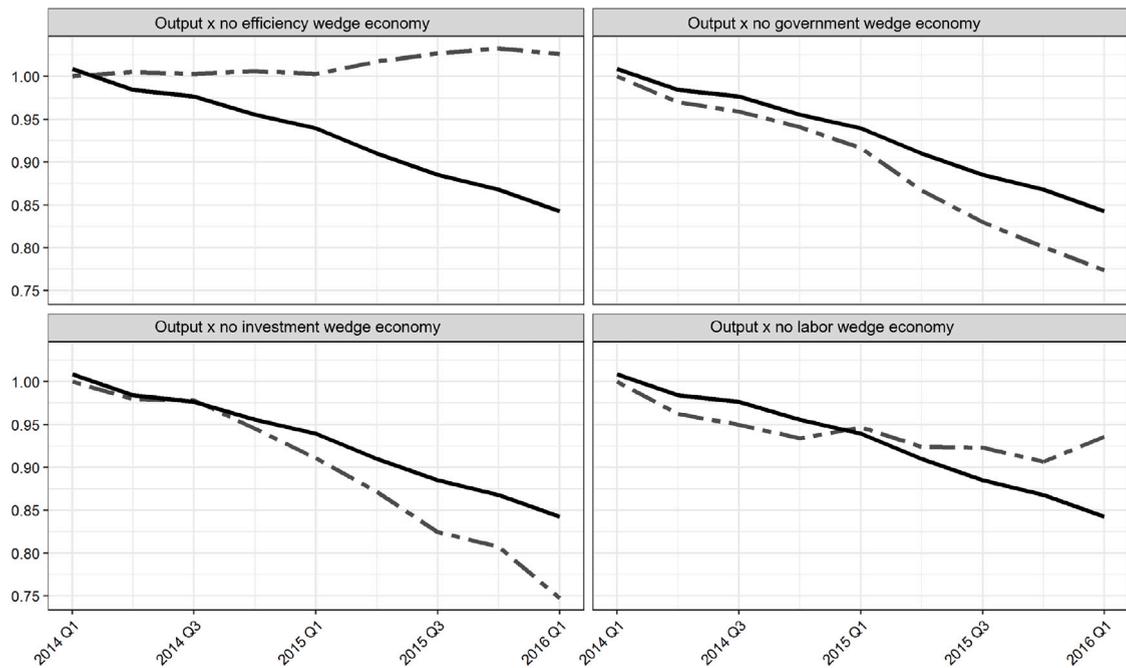


Fig. D.4. 2014 crisis: Output and one wedge off economies. Figure shows observed output and its counterfactual during 2014 Recession if only one wedge is not active. Up and left: Counterfactual output if only efficiency wedge is not active. Up and right: Counterfactual output if only government wedge is not active; Bottom and left: Counterfactual output if only investment wedge is not active; Bottom and right: Counterfactual output if only labor wedge is not active. *Source:* Own elaboration.

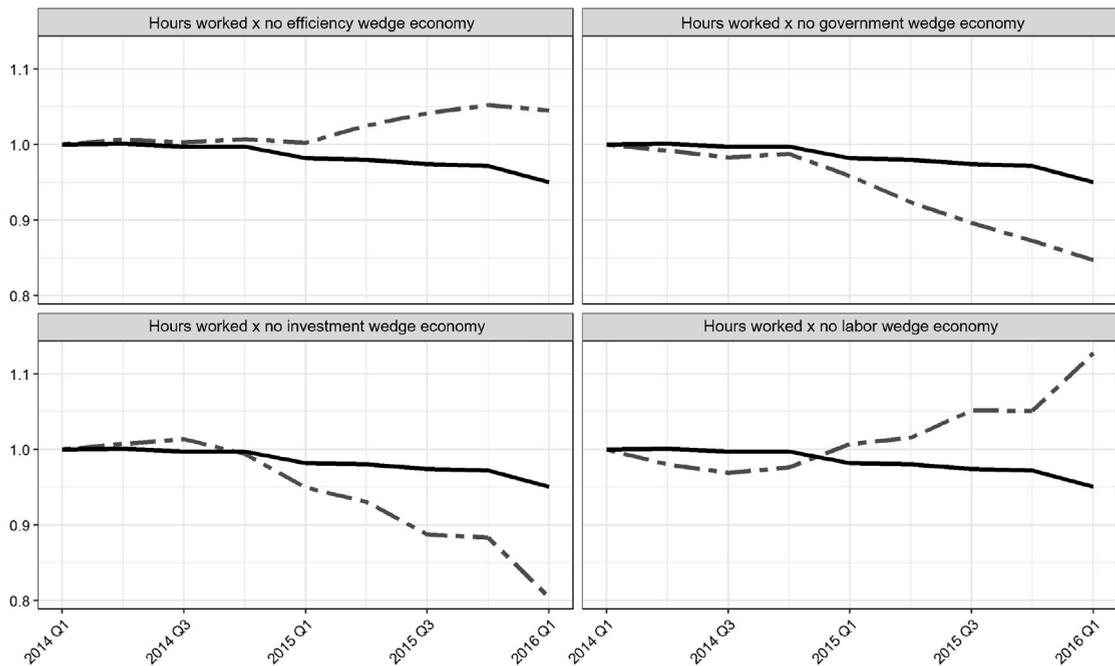


Fig. D.5. 2014 crisis: Hours worked and one wedge off economies. Figure shows observed hours worked and its counterfactual during 2008 Recession if only one wedge is not active. Up and left: Counterfactual hours worked if only efficiency wedge is not active. Up and right: Counterfactual hours worked if only government wedge is not active; Bottom and left: Counterfactual hours worked if only investment wedge is not active; Bottom and right: Counterfactual hours worked if only labor wedge is not active. *Source:* Own elaboration.

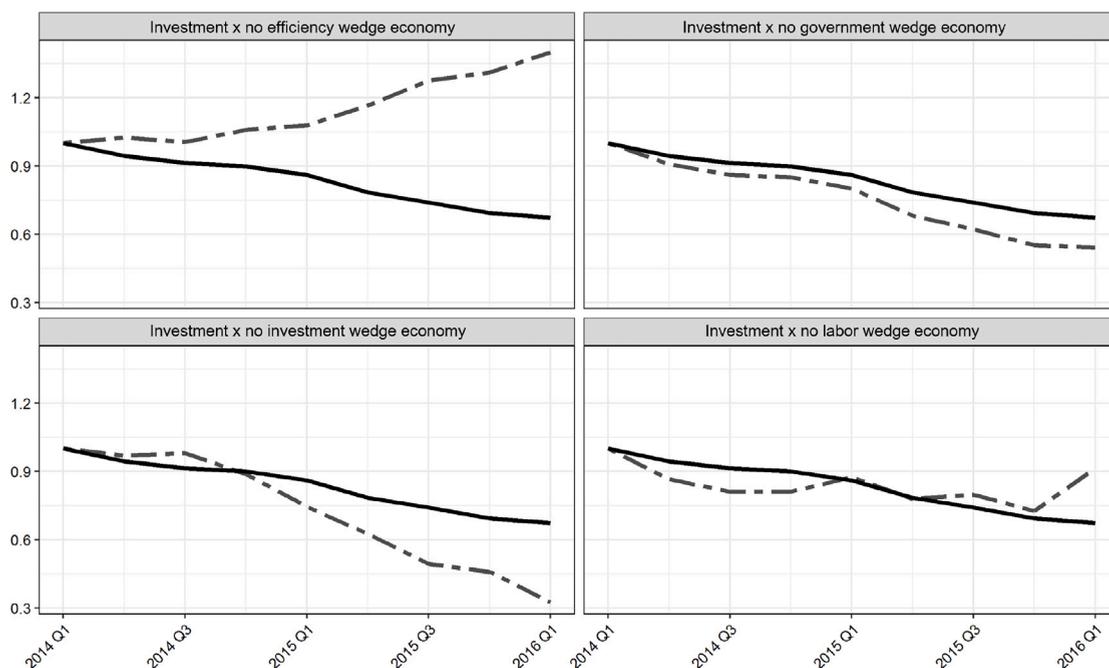


Fig. D.6. 2014 crisis: Investment and one wedge off economies. Figure shows observed investment and its counterfactual during 2008 Recession if only one wedge is not active. Up and left: Counterfactual investment if only efficiency wedge is not active. Up and right: Counterfactual investment if only government wedge is not active; Bottom and left: Counterfactual investment if only investment wedge is not active; Bottom and right: Counterfactual investment if only labor wedge is not active.

Source: Own elaboration.

Appendix D. One wedge off economies

See Figs. D.1–D.6.

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