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Abstract

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How does hyperinflation shock the economy?: Panel VAR Approach *

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Abstract

Using 48 country data for the period 1800-2010, we empirically investigate the effect of hyperinflations on the public debt, the primary surplus, and the real economy. Estimating a panel vector-autoregressive (VAR) model, we find that (i) hyperinflations permanently reduce public debt-to-GDP ratios; (ii) the reduction is closely related to the increase in the primary balances in response to hyperinflations; (iii) however, hyperinflations accompany dampening effects on the real economy, reducing GDP.

Keywords: hyperinflation, panel VAR, public debt, fiscal reform

JEL classification: E31; E51; E63

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1 Introduction

How does the real economy respond to hyperinflations? Do hyperinflations reduce or increase government debt? Do primary surplus and output increase or fall? Studying some episodes of hyperinflations, Sargent (1982) and Dornbusch and Fisher (1986) argue that, rather than purely monetary reforms, monetary and fiscal policies must be coordinated to end hyperinflations. However, there is little empirical evidence to shed light on these issues. In this paper, we formally investigate this orthodox view conducting a detailed empirical analysis how fiscal variables and the real economy reacts to hyperinflations.

Dual equilibria problems have been focused on in a voluminous number of the theoretical literature. According to this literature, there may exist both a low and high inflation equilibrium when government finances the deficit through seigniorage. Further, the stability of these two equilibria has been investigated under rational expectation or learning frameworks in this inflation finance literature. This strand of literature also has studied why a government would choose the wrong side of the inflation Laffer curve.¹

Another strand of hyperinflation literature has emphasized the role of sizeable fiscal imbalances as a cause of hyperinflations. The seminal paper by Cagan (1956), which studied seven of the eight hyperinflations that took place between 1920 and 1946, asserts that a government may have a short-run benefit to exceed the revenue-maximizing rate of money growth if expectations of inflation are adoptive. Sargent (1982) stresses the role of seigniorage as a potential cause of hyperinflation burst. According to Dornbusch and Fischer (1986), the German hyperinflation shows the clear pattern of massive deficits continuing for several years, leading to increasing inflation, increasing velocity and falling real tax revenue until some event leads to exchange rate collapse and hence a completely uncontrolled inflation. Havrylyshyn et al. (1994) find that after the Soviet Union dissolved in 1991, in Ukraine, inflation tax has been used to finance fiscal deficits and this lead to accelerating inflation. Loyo (1999) finds the case where inflation explodes because of the fiscal effects of monetary policy, asserting that Brazil in the late 1970s and early 1980s serves as this case.² Fischer et al. (2002) report a strong positive relationship between seigniorage, deficits and inflation using annual observations for high-inflation countries over the period 1960-1995.³

The main stream of empirical literature on hyperinflations has concentrated on estimating the money demand function ever since Cagan (1956). In the time-series analysis, however, it has been rarely mentioned how fiscal responses are related to end hyperinflations. Furthermore, the effect on the real economy has been neglected even in theory. For example, inflation finance models studying hyperinflationary periods, including Cagan (1956), Sargent and Wallace (1981), and Evans and Yarrow (1981), implicitly assume that the change of real income is relatively unimportant because prices and money increases astronomically.

Our paper has three distinctive features. First, we investigate all hyperinflations for

¹For a brief review of recent literature on learning, see Arce (2009), Adam et al. (2006), and Marcet and Nicolini (2003) among others.

²In his model, hyperinflation is caused by the interest bill on public debt and debt rollover, rather than seigniorage or primary budget deficits.

³The relationship between fiscal deficit and high inflation has been investigated. For example, Bruno and Easterly (1998) find that growth falls sharply when inflation exceeds 40 percent. Catao and Terrones (2005) find a strong positive relationship between the budget deficit and inflation during high inflation episodes.

countries which have officially possible data sets, in contrast to the existing literature that focuses only on some selected events of one or small numbers of countries. We investigate the effect of hyperinflations in 48 countries covering more than two hundred years: 1800-2010. We construct two measures of annual episodes as hyperinflation shocks. Second, we employ a panel structural vector-autoregressive (SVAR) approach, using the above-mentioned internationally pooled time series data. While the duration of hyperinflation is too short to allow estimation on one or small numbers of countries, our panel SVAR approach is practical for a large panel of countries. Third, our identification strategy is based on the narrative method, implemented in the government spending multiplier literature such as in Ramey (2011). This strategy enables us to identify the timing of hyperinflations in a VAR model.⁴

Our benchmark VAR model consists of four variables: the hyperinflation dummy, the public debt-to-GDP ratio, the primary surplus-to-GDP ratio, and real GDP. The public debt-to-GDP ratio is an important variable because it represents the summation of the past and the current fiscal imbalance. Observing the response of this variable, we can detect whether hyperinflations lessen the government's burden.⁵ The primary surplus-to-GDP ratio must be included in order to trace the government's behavior in response to hyperinflation shocks. Real GDP is included to investigate how hyperinflations affect the real economy.

Main results based on a panel VAR estimation can be summarized as follows. First, we find that hyperinflation shocks are associated with the reduction of the debt-to-GDP ratio. However, the debt-to-GDP ratio appears to increase in the very short run. Second, we find that the primary surplus permanently increases in response to hyperinflation shocks. We conjecture that the reduction of the debt-to-GDP ratio may be ascribed to this fiscal policy. In a robustness-check analysis, we also find that government revenue increases and government expenditure decreases after hyperinflations. Third, we find that real GDP considerably decreases compared to the peace-time level.

The remainder of the paper is organized as follows. Section 2 explains simple structural interpretation. Section 3 describes the panel-VAR model and the identification scheme. Section 4 displays the main results. Section 5 shows the robustness check. Section 6 concludes the paper.

2 Simple structural interpretation

Our simple model borrows the key idea from Sargent (1982): monetary and fiscal policies must be coordinated because the government faces a budget constraint. This implies that the central bank cannot cure inflations and hyperinflations without the assistance from the fiscal authority. In a simple model, we aim to explain how fiscal authority restores the economy under limited seigniorage. Further, we also investigate the detrimental effect of hyperinflations on GDP, which has been by and large ignored in the literature.

⁴Sargent (1992) and Dornbusch and Fisher (1986) argue the central role of the fiscal as well as monetary problems in causing hyperinflations. However, it is not within the scope of this paper to investigate how fiscal and monetary actions affected the hyperinflationary burst. As Sargent (1992) noted, however, there is a possibility of changes in the rules of the game under which fiscal policy had to be conducted.

⁵Aizenman and Marimon (2011) investigate how the government may be tempted to inflate away debt burden showing some of actual US World War II debt reductions by inflation.

2.1 Basic setup

Suppose that a government faces debt as a fraction of nominal GDP: d_t ($\equiv \frac{D_t}{P_t Y_t}$, where P_t and Y_t denote the price level and output). There are two ways for a government to reduce this debt-to-GDP ratio. First, As a fraction of GDP, a government can raise s_t ($\equiv \frac{S_t}{P_t Y_t}$) by increase in primary surplus. Second, a government can raise $\frac{(M_t - M_{t-1})}{P_t Y_t}$ by printing money. Denoting $\frac{M_t}{P_t Y_t}$ as m_t , we can represent this term as

$$\left(m_t - \frac{R_{m,t}}{\zeta_t} m_{t-1} \right), \quad (1)$$

where $R_{m,t}$ is the inverse of inflation (P_{t-1}/P_t) and ζ_t is the growth rate of Y_t .

We can represent the government budget constraint as

$$d_t = \frac{R_t R_{m,t}}{\zeta_t} d_{t-1} - s_t - \left(m_t - \frac{R_{m,t}}{\zeta_t} m_{t-1} \right). \quad (2)$$

The coefficient term, $\frac{R_t R_{m,t}}{\zeta_t}$, of the past debt-to-GDP ratio in the right-hand side is sometimes called the discount factor, which represents whether or not the economy is dynamically efficient. For example, when $R_t R_{m,t} < \zeta_t$, which we call dynamic efficient, the debt-to-GDP ratio can be lowered without the government actions.⁶ In the tradition of Cagan (1956), we define the money demand function⁷ as

$$m_t = f(R_{m,t}), \quad (3)$$

where $f(R_m)$ is the real cash balance that changes in the direction opposite to changes in the return on assets other than money.

Next, we consider the steady state where the variables in terms of the GDP ratio are constant.⁸ The steady state is important because we can analyze the coordination between monetary and fiscal authorities, given constant d and ζ . In the empirical section, the interpretation of the results heavily depends on the steady-state features: for example, we trace the s to analyze how the fiscal authority behaves in the long run.

In this steady state, the relationship between debt-to-GDP ratio and money demand becomes

$$\left(\frac{R R_m - \zeta}{\zeta} \right) d = s + f(R_m) \left(\frac{\zeta - R_m}{\zeta} \right). \quad (4)$$

When the discount factor is less than one in the steady state ($R R_m > \zeta$), the economy is dynamically inefficient. In this case, when the debt-to-GDP ratio is positive, the primary surplus or seigniorage revenue also should be positive. The second term in the right-hand side is the rate of seigniorage revenues as a fraction of GDP, where $f(R_m)$ is the base of the inflation tax and $\frac{\zeta - R_m}{\zeta}$ is the inflation tax rate. The so-called ‘unpleasant monetarist arithmetic’ can be explained in this equation: if the central bank performs an open market sale of bonds in the short run and the government does not increase the primary surplus to lower debt, monetary authority should increase money supply in the long run.

⁶See Domar (1944) as a pioneer work for this issue.

⁷Microfoundation for this equation can be easily found in the existing literature. See, for example, Obstfeld and Rogoff (1996), and Ljungqvist and Sargent (2012) among others.

⁸For example, we consider the economy where debt-to-GDP ratio is constant but it does not necessarily mean that nominal debt, price level, and real GDP are also constant.

2.2 Inflation, hyperinflation, and fiscal reform

In this subsection, we investigate the effect of hyperinflation. Suppose the economy stays in a low inflation equilibrium as in equation (4). Sargent and Wallace (1981) show that, under rational expectations, the high inflation equilibrium is stable and the low inflation equilibrium unstable. In other words, if the economy deviates from the low inflation equilibrium, it converges to the high inflation equilibrium.

We specify the money rule as follows:

$$M_t = \theta_L M_{t-1}, \quad \forall t < 0 \quad (5)$$

where θ_L is a small constant term.

Suppose, at $t = 0$, the government experiences sizeable fiscal imbalances and hence a high debt-to-GDP ratio. Therefore, the government is enticed to inflate it away with $\theta_t \gg \theta_L$ since $t = 0$. If it is not fully anticipated by the economy, the seigniorage revenue may increase more, but it can produce higher inflation in both the present and the future.⁹

Under the dual equilibria model, which is a reflection of the Laffer curve, the deviation from the low inflation equilibrium implies that the economy can converge to and be stucked in a high inflation trap ($R_{m,t} < R_{m,t-1}$ for $t \in \{0, \dots, T\}$).¹⁰ Sargent (1982) argues that, in a rational expectation model, the only way to get back to the low inflation is the coordination between monetary policy and fiscal policy.^{11,12} In other words, the monetary authority should commit to keep inflation in a certain rate, and the fiscal authority should commit to service the debt with primary surplus.¹³

To investigate the effect of hyperinflation on the government stance and the real economy, we assume the following features: (A) hyperinflation permanently lowers output level but not growth rate and (B) monetary authority commits to maintain constant money growth to keep low inflation rate.

The first assumption calls for the issue that the real rates of return on government bonds exceed the economy's rate of growth at least in the short run. The monetary and fiscal authorities confront with the choices whether to levy taxes or reduce purchase or print currency to pay the interest.

If we assume that hyperinflation occurs at $t = T$ ($P_T \gg P_{T-1}$), the government budget constraint can be written as follows:

$$d_T = \frac{R_T R_{m,T}}{\zeta_T} d_{T-1} - s_T - \left(m_T - \frac{R_{m,T}}{\zeta_T} m_{T-1} \right), \quad (6)$$

where we should consider the effect of hyperinflation on the real output. Assumption (A) implies that hyperinflation is harmful to the real output, namely,

$$\zeta_T \ll \zeta. \quad (7)$$

⁹For example, Catao and Terrones (2005) find that, during high inflation episodes, the budget deficit and inflation comoves.

¹⁰The literature on hyperinflation has been focused on the existence of both a high and a low inflation equilibrium in the economy that government finances the deficit or debt through seigniorage.

¹¹Investigating some selective countries, Sargent (1982) and Dornbusch and Fischer (1986) narratively show that reforms both in monetary and fiscal authorities are important to end hyperinflations.

¹²There are other possible ways to rule speculative hyperinflations out. Obstfeld and Rogoff (1983) show that speculative paths can be eliminated provided that government fractionally backs the currency by standing ready to redeem each dollar for a small amount of capital.

¹³Bruno and Fischer (1990) also assert that the monetary anchor cannot be replaced by a fiscal anchor.

The effects of the past debt and primary surplus as fractions of nominal GDP on current debt-to-GDP ratio are lessened as far as $R_{m,T}^{-1} > |\zeta_T|$. The volume of seigniorage depends on how close the economy is to the hyperinflation steady state. If the economy has already passed the peak of the Laffer curve, the seigniorage can even decrease. The high-inflation steady state has ‘perverse’ properties since an high inflation does not lead to increase in seigniorage.¹⁴ Once hyperinflation occurs, the second assumption restricts the monetary authority not to increase base money more to service the debt:

$$M_t = \theta_L M_{t-1}, \quad \forall t \geq T, \quad (8)$$

which implies that the fiscal authority has no choice: It must increase primary surplus.

At $t = T + 1$ under mild inflation ($P_{T+1} > P_T$) but still a lower GDP growth rate ($\zeta_{T+1} < \zeta$), the government budget constraint becomes

$$d_{T+1} = \frac{R_{T+1} R_m}{\zeta_{T+1}} d_T - s_{T+1} - \left(\frac{\zeta_{T+1} - R_m}{\zeta_{T+1}} \right) m, \quad (9)$$

where $m = m_T = m_{T+1}$ from assumption (B). Given constant R_m , the first term in the right-hand side increases because of low growth rate of real GDP. Furthermore, under constant m and R_m , seigniorage must decrease, again because of the low growth rate of real GDP. Therefore, the fiscal authority should increase the primary surplus to lower the debt-to-GDP ratio and hence let the economy move towards the low inflation steady state. Since $t = T + 2$, the economy converges to the steady state.

3 Estimation methodology and data

In this section, we explain our estimation methodology and data.

3.1 Panel VAR model

In order to reveal a common effect of hyperinflation on debt dynamics worldwide, we employ an unbalanced panel VAR model. The data consist of gross public debt as well as primary balance as a share of GDP, the real GDP growth rate, and hyperinflation. The panel VAR model can be described as

$$X_{i,t} = c_i + A_1 X_{i,t-1} + \dots + A_p X_{i,t-p} + u_{i,t} \quad (10)$$

where $X_{i,t}$ is a (4×1) vector of endogenous variables that comprises the hyperinflation year variable, the debt-to-GDP ratio, the primary balance-to-GDP ratio, and the GDP growth rate for a given year t and country i . c_i is a vector of constants that captures the fixed effect for each country. In contrast, A_j , a matrix with VAR lag coefficients, is assumed to be common across countries. Furthermore, $u_{i,t}$ is a vector of reduced form residuals such as $E(u_{i,t}) = 0$, $E(u_{i,t} u'_{i,t}) = \Sigma$, and $E(u_{i,t} u'_{j,t}) = 0, j \neq i$. For the lag length p , we set it to be one in consideration of annual data. To ensure the stationarity of the data, the debt-to-GDP ratio and the primary balance-to-GDP ratio are incorporated in a first-difference form. In addition, following Ramey (2011), we introduce a hyperinflation

¹⁴Reviewing hyperinflation literature, Arce (2009) also notes that sometimes seigniorage falls while inflation still grows at increasing rates.

dummy variable that takes 1 if the inflation rate exceeds a certain level as a proxy of hyperinflation, and zero otherwise.¹⁵ This is following Ramey (2011) in which fiscal news dummy is incorporated into the VAR model as an endogenous variable. This “dummy variable” approach uses narrative evidence to date large and exogenous shocks in the VAR model.

In this study, the estimation is performed via Bayesian Markov Chain Monte Carlo (MCMC) method, especially Gibbs sampler. Given $\beta = [vec(c_i), vec(A_1), \dots, vec(A_p)]$, $\tilde{X}_t = \{X_{i,-p+1}, \dots, X_{i,t}\}$, and Σ , the Gibbs sampler allow us to generate random samples from the posterior distribution $\pi(\beta, \Sigma | \tilde{X}_T)$ as follows:¹⁶

1. Set initial values in $\beta^{(0)}, \Sigma^{(0)}$ and $l = 1$.
2. Generate $\beta^{(l+1)}$ form $\pi(\beta | \Sigma^{(l)}, \tilde{Y}_T)$.
3. Generate $\Sigma^{(l+1)}$ form $\pi(\Sigma | \beta^{(l+1)}, \tilde{Y}_T)$.
4. Return to step 2 until the number of iteration reaches N times,

where N is set to be 20000 and the first $N_0 = 15000$ samples are discarded as burn-in samples.

With respect to the identification of structural shocks, we simply adopt Cholesky decomposition of Σ because we are interested only in the impulse response function of endogenous variables to hyperinflation dummy.

3.2 Data

Cagan (1956) defined hyperinflations as periods during which the price level of goods in terms of money rises at a rate at least 50 percent per month. As a benchmark measure of hyperinflation, we set a dummy in the year when the monthly inflation rate exceeds 50 percent, referring the data from Hanke and Krus (2013). To check the results’ robustness, we build a second measure of hyperinflation, following Reinhart and Rogoff (2011), adding the episodes if the annual inflation exceeds 500 percent. This second measure is necessary to investigate some countries, such as Indonesia and Japan, that do not have monthly data but experienced extremely high annual inflation. Furthermore, there are many episodes that countries experienced very high annual inflation although the monthly inflation stay less than 50 percent. The data on the debt-to-GDP ratio, the primary surplus-to-GDP ratio, and real GDP growth rate all come from Mauro et al. (2013).

4 Main results

Figure 1 presents the impulse responses (IRs) to hyperinflation shocks. Estimated mean IRs and 90 percent credible interval bands are shown for each variable. IRs are given for the first 12 years. Panel (A) represents the response of the hyperinflation dummy

¹⁵In this study, we construct two types of hyperinflation dummies. The first dummy is following Cagan (1956) and takes one when the monthly inflation rate is more than 50 percent. In addition to the first one, the samples in which the annual inflation rate exceed 500 percent are also introduced to the second dummy by following the definition of Reinhart and Rogoff (2011).

¹⁶For the prior distribution, we simply employ the Normal-Wishart diffuse distribution.

variable to hyperinflation shocks. The persistency comes from the reason that, generally speaking, hyperinflation does not end within a year.

As debt accumulates, policymakers would be tempted to inflate it away. Aizenman and Marion (2011) show that high inflation played an important role in reducing US World War II debts from around 100 percent to 40 percent within a decade. In Panel (B), at a glance, hyperinflations also seem to play an important role in reducing debt. Our result indicates that hyperinflations permanently reduce the debt-to-GDP ratio by 12 percent on average. However, it is surprising that hyperinflations feature a positive response of the debt-to-GDP ratio at impact. In other words, hyperinflations do not reduce the debt-to-GDP ratio at least in the short run. We investigate further why the debt-to-GDP ratio increases in the very short run in the robustness-check subsection.

As can be seen in Panel (C), primary surplus significantly starts to increase one year later and converges to the new steady state level, 5 percent higher than before. This finding is consistent with Sargent (1992): he stresses that the essential measures that ended hyperinflation in each of Germany, Austria, Hungary, and Poland were both the creation of an independent central bank and a simultaneous alteration in the fiscal policy regime. In our interpretation, the estimated positive primary balance represents this kind of fiscal reforms. Turning back to zero of the hyperinflation dummy variable in Panel (A) also means that inflation is stabilized to a low level. In other words, monetary reforms succeed in stabilizing inflation.

Finally, moving to Panel (D), we find that the GDP response is negative, decreasing as much as 4 percent at impact and continuing to slowly decrease to the new steady state, which is 7.5 percent lower than before. In most of hyperinflation literature, hyperinflation has been considered as a simple monetary phenomenon.¹⁷ In other words, studies on the money market rather than the real economy has been more focused on. Even Cagan (1956) explains hyperinflations as the astronomical increases in prices and money dwarf the changes in real factors. Our finding shows that the relative size compared to hyperinflation could be negligible but the actual decrease in real GDP itself is sizeable.

[Insert Figure 1]

5 Robustness

In this section, we test the robustness of the finding that hyperinflations have significant effects on the debt-to-GDP ratio, the primary surplus, and output. First, we examine how hyperinflation shocks affect the components of primary surplus. Second, as an alternative of narrative measure, we use the end-year of hyperinflations, which provides some evidence why hyperinflations end suddenly. Third, we investigate the sensitivity of the results using an alternative measure of hyperinflations.

5.1 Increasing revenue or decreasing expenditure

In the benchmark case, we find that primary surplus increases in response to hyperinflation shocks. In this subsection, we investigate this issue further examining how hyperinflation shocks affect each component of primary surplus. We estimate a five-variable

¹⁷See, for example, Sargent and Wallace (1973), and Evans and Yarrow (1981) among others.

VAR model with the hyperinflation dummy variable, the debt-to-GDP ratio, government revenue and government expenditure as fractions to GDP, and real GDP. The second to fifth variables are in difference forms as in the benchmark case.

The results are presented in Figure 2. Panels (A), (B), and (F) respectively display the hyperinflation, the debt-to-GDP ratio, and real GDP, which mirrors the ones in the benchmark case. Panels (C) and (D) show the estimated responses of government revenue and government expenditure, respectively. It appears that government revenue increases but government expenditure decreases. The first finding is inconsistent with Tanzi (1977), which points out that inflation can lower real tax revenues.¹⁸ On the other hand, the second finding is in parallel with Patinkin (1993) that emphasizes the negative effect of inflation on the real value of government spending.

[Insert Figure 2]

5.2 Timing

In the benchmark result, we find that the debt-to-GDP ratio increases at impact although the economy experiences extremely high inflation. One possible reason is that other factors may affect the debt-to-GDP ratio and could be correlated with our measure of exogenous hyperinflation shocks. For example, the short-run increase in the debt-to-GDP ratio in the benchmark case may reflect that government has been facing huge fiscal imbalances and high seigniorage is required to finance the debt. However, the Laffer curve implies that once the inflation rate increases, at some point, the seigniorage decreases. In this case, given a certain level of fiscal deficit, the debt-to-GDP ratio rather increases. Our hyperinflation shock may capture this severe situation that the government is facing.

Consider now a comparison of the effects of hyperinflations based on the timing. In many cases, hyperinflation did not end in one year. As discussed in Section 2, in a rational expectation equilibrium, the low-inflation equilibrium should be obtained at once. Therefore, to investigate how the hyperinflation ends, we take the end year of hyperinflations as a hyperinflation dummy.

Figure 3 shows the path of each variable after the alternative hyperinflation shocks. In Panel (A), by construction, the end-year variable of hyperinflations has no persistence. In Panel (B), in contrast to the benchmark case, the debt-to-GDP ratio starts to decrease since the impact year. In Panel (C), furthermore, the primary surplus-to-GDP ratio jumps to the 3.8 percent level at the impact year. Finally, real GDP in Panel (D) is 5 percent lower than the original steady state, but its decline is much smaller than the benchmark case.

Overall, this robustness-check analysis gives an answer how hyperinflation ends. The recovery of the economy is not the answer because hyperinflations accompany the economic depression. The result implies that the effectiveness to end hyperinflation depends on the credibility in the stabilization policies. The end of hyperinflations means that the economy returns to the low-inflation equilibrium with a certain money growth. Hence, the fiscal authority should increase primary surplus to sustain the government budget constraint.

[Insert Figure 3]

¹⁸According to the Olivera-Tanzi effect (Olivera, 1967; Tanzi 1977), the government's deficit is influenced by past inflation: high rates of inflation can lead to substantial losses in government revenue.

5.3 Alternative definition of hyperinflation

In the benchmark case, hyperinflation years includes if the monthly inflation rate a certain year exceeds 50 percent. In this subsection, we define hyperinflations as episodes where a monthly inflation rate exceeds 50 percent or the annual inflation rate exceeds 500 percent. Figure 4 presents the IRs using this alternative measure of hyperinflations. Not surprisingly, we have almost the same results as those in the benchmark case.

[Insert Figure 4]

6 Concluding remarks

Sargent (1982) and Dornbusch and Fischer (1986) argue that the fiscal reforms are crucial to end hyperinflation and stabilize the economy. In this paper, we provide formal evidence for this view using formal tests. We investigate the effect of hyperinflations on public debt, the primary surplus, and the real economy in the framework of a panel VAR model. We identify hyperinflation shocks using narrative approach.

Our results suggest that hyperinflation leads to government reforms. We find that the primary surplus as a share of GDP increases 5 percent higher than before. Furthermore, public debt as a fraction of GDP also permanently decreases. Our results support the idea by Sargent (1992) and Dornbusch and Fischer (1986): coordination between monetary and fiscal authority is necessary to end hyperinflation. However, it appears that hyperinflation dampens the economy, decreasing real GDP as much as 7.5 percent. This implies that hyperinflation is not a monetary phenomenon: it has a detrimental effect on the real economy. The economic recession is another important factor that fiscal authority should consider to maintain the government budget constraint.

References

- Adam, K., Evans, G. W., Honkapohja, S. (2006): "Are Hyperinflation Paths Learnable?" *Journal of Economic Dynamics & Control*, 30, pages 2725-2748.
- Aizenman, J., Marion, N. (2011): "Using Inflation to Erode the U.S. Public Debt," *Journal of Macroeconomics*, 33, pages 524-541.
- Arce, O. J. (2009): "Speculative Hyperinflations and Currency Substitution," *Journal of Economic Dynamics & Control*, 33, pages 1808-1823.
- Bruno, M., Easterly, W. (1998): "Inflation Crises and Long-Run Growth," *Journal of Monetary Economics*, 41, pages 3-26.
- Bruno, M., Fisher, S. (1990): "Seigniorage, Operating rules, and the High Inflation Trap." *Quarterly Journal of Economics* 105, pages 353-374.
- Cagan, P. H. (1956): "The Monetary Dynamics of Hyperinflation," In: Friedman, M. (Ed.), *Studies in the Quantity Theory of Money*. University of Chicago Press, Chicago.

- Catao, I. A. V., Terrones, M. E. (2005): "Fiscal Deficits and Inflation," *Journal of Monetary Economics*, 52, pages 529-554.
- Cardoso, E. A. (1998): "Virtual Deficits and the Patinkin Effect," *IMF Staff Papers*, 45, pages 619-646.
- Domar, E. D. (1944): "The "Burden of the Debt" and the National Income," *American Economic Review* 34, pages 798-827.
- Dornbusch, R., Fischer, S. (1986): "Stopping Hyperinflations Past and Present," *Review of World Economics*, 122 (1), pages 1-47.
- Evans, J. L., Yarrow, G. K. (1981): "Some Implications of Alternative Expectations Hypotheses in the Monetary Analysis of Hyperinflations," *Oxford Economic Papers*, 33, pages 61-80.
- Fischer, S., Sahay, R., Vegh, C. A. (2002): "Modern Hyper- and High Inflations," *Journal of Economic Literature*, 40, pages 837-880.
- Hanke, S. H., Krus, N. (2013): "World Hyperinflation," *The Handbook of Major Events in Economic History*, London: Routledge Publishing.
- Havrylyshyn, O., Miller, M., Perraudin, W. (1994): "Deficits, Inflation, and the Political Economy of Ukraine," *Economic Policy*, 19, pages 353-401.
- Marcet, A., Nicolini, J.P. (2003): "Recurrent Hyperinflations and Learning," *American Economic Review*, 93, pages 1476-1498.
- Mauro, P., Romeu, R., Binder, A. J., Zaman, A. (2013): "A Modern History of Fiscal Prudence and Profligacy," *IMF Working Papers* 13/5, International Monetary Fund.
- Lin, H. Y., Chu, H. P., (2013) "Are Fiscal Deficits Inflationary?," *Journal of International Money and Finance*, 32 (C), pages 214-233.
- Ljungqvist, L., Sargent, T. J. (2012): "Recursive Macroeconomic Theory, Third Edition," MIT Press Books, The MIT Press, edition 3, volume 1.
- Loyo, E. H. M. (1999): "Tight Money Paradox on the Loose: A Fiscal Hyperinflation," unpublished, Kennedy School of Government.
- Obstfeld, M., Rogoff, K. (1996): "Foundations of International Macroeconomics," Cambridge MA, The MIT Press.
- Obstfeld, M., Rogoff, K. (1983): "Speculative Hyperinflations in Maximizing Models: Can We Rule Them Out?" *Journal of Political Economy*, 91, pages 675-687.
- Olivera, J. H. G. (1967): "Money, Prices and Fiscal Lags: a Note on the Dynamics of Inflation," *BNL Quarterly Review*, 20, pages 258-267.
- Patinkin, D. (1993): "Israel's Stabilization Program of 1985, or Some Simple Truths of Monetary Theory," *Journal of Economic Perspective*, 7, pages 103-128.

- Ramey, V. A., (2011): "Identifying Government Spending Shocks: It's All in the Timing," *The Quarterly Journal of Economics*, 126, pages 1-50.
- Reinhart, C. M., Rogoff, K. S. (2011): "From Financial Crash to Debt Crisis," *American Economic Review*, 101, pages 1676-1706.
- Sargent, T. J. (1982): "The Ends of Four Big Inflations," in Robert Hall ed., *Inflation, Causes and Effects*, Chicago: University of Chicago Press, pages 41-98.
- Sargent, T. J., Wallace, N. (1981): "Some Unpleasant Monetarist Arithmetic," Federal Reserve Bank of Minneapolis *Quarterly Review*, pages 1-17.
- Sargent, T. J., Wallace, N., (1973): "Rational Expectations and the Dynamics of Hyperinflation," *International Economic Review*, 14, pages 328-350.
- Tanzi, V. (1977): "Inflation, Lags in Collection, and the Real Value of Tax Revenue," *IMF Staff Papers*, 24, pages 154-167.

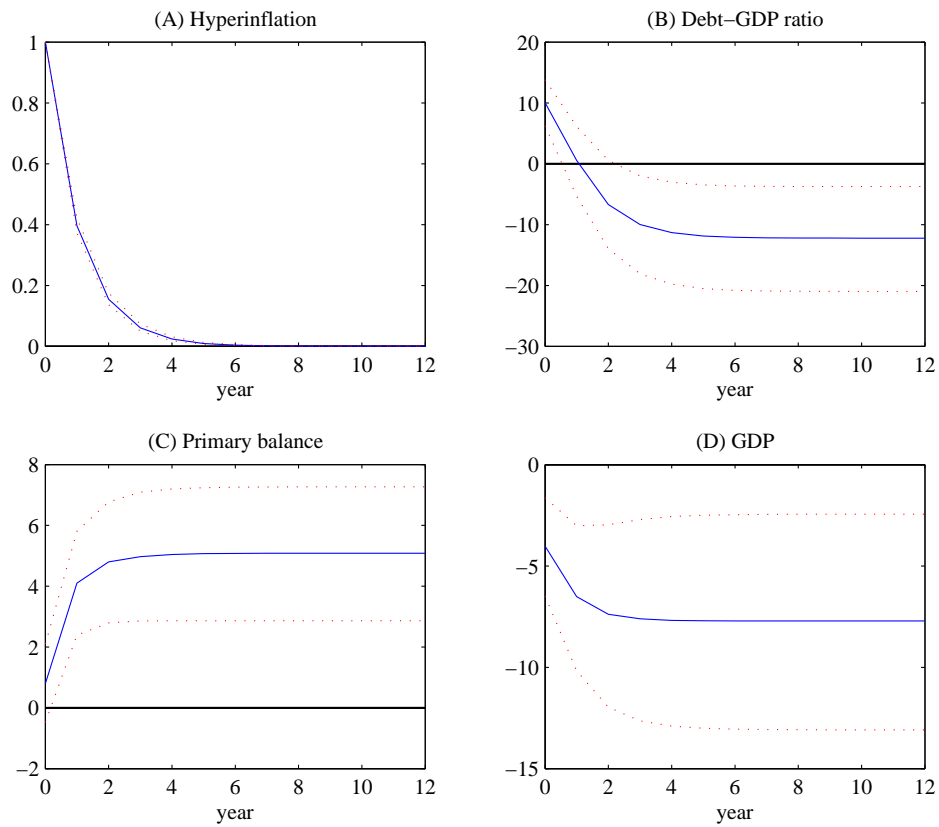


Fig. 1. Impulse responses to hyperinflation shocks.

Note: Blue lines indicate the mean responses of each variable. The red dotted lines represent 90 percent credibility intervals.

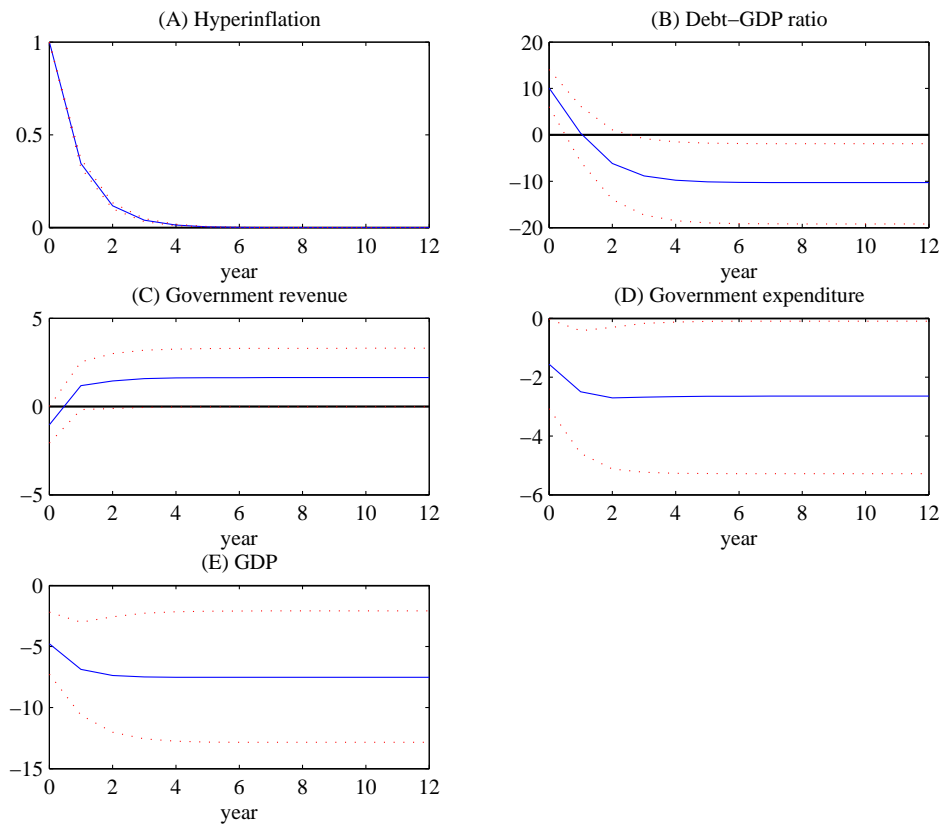


Fig. 2. Impulse responses using 5 variable VAR model.
 Note: Blue lines indicate the mean responses of each variable. The red dotted lines represent 90 percent credibility intervals.

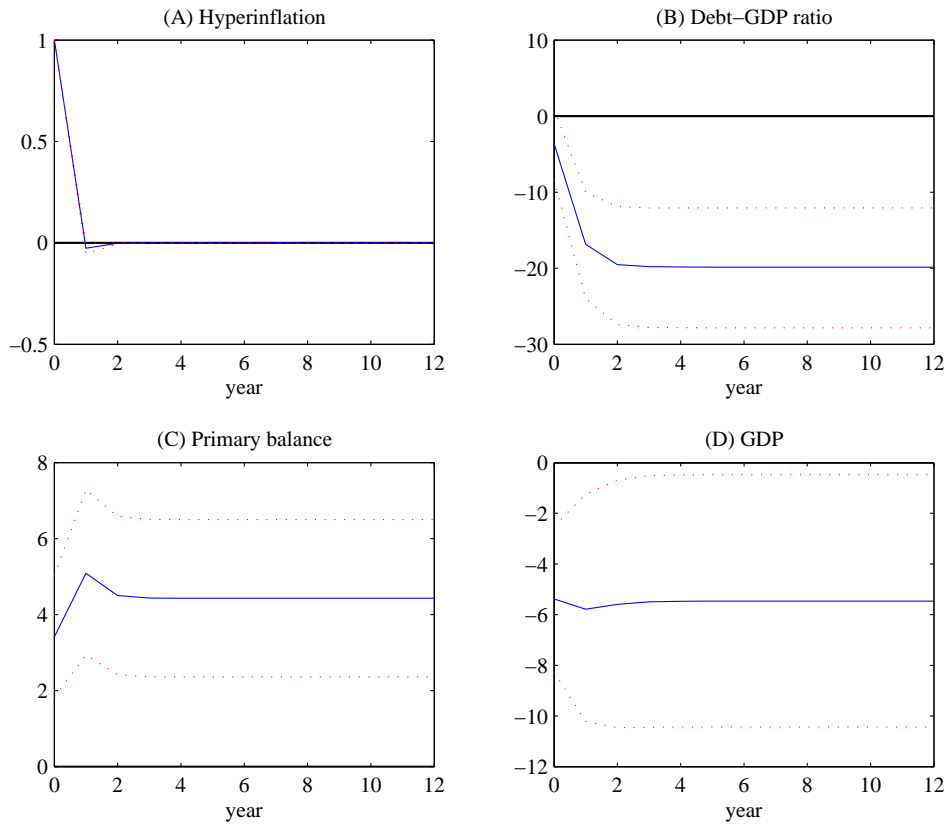


Fig. 3. End-year dummy as Hyperinflation shocks.

Note: Blue lines indicate the mean responses of each variable. The red dotted lines represent 90 percent credibility intervals.

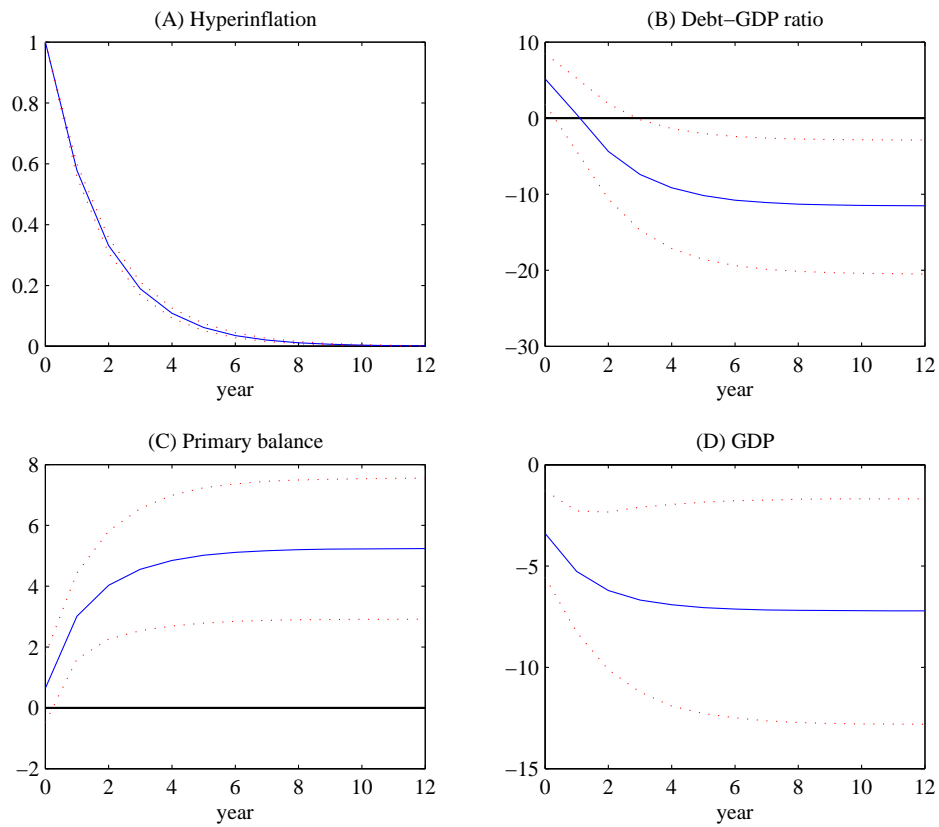


Fig. 4. Alternative measure of Hyperinflations.

Note: Blue lines indicate the mean responses of each variable. The red dotted lines represent 90 percent credibility intervals.