INSTITUTO DE ECONOMÍA

DOCUMENTO de TRABAJO

464

2015

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www.economia.puc.cl • ISSN (edición impresa) 0716-7334 • ISSN (edición electrónica) 0717-7593

The flypaper effect is not a puzzle*

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September 3, 2015

Abstract

This note provides, in the context of an example, a new theoretical explanation of the flypaper effect by incorporating dynamic stochastic features into the conventional framework of local public finances. Under these circumstances, the flypaper effect is not an anomaly, but a natural optimizing behavior within the "traditional theory of grants-in-aid". When shocks to intergovernmental transfers are more permanent than those affecting private income, an increase in intergovernmental transfers shifts public goods provision upward much more than an equivalent change in private income.

Keywords: Intertemporal local fiscal behavior, stochastic processes, flypaper effect.

JEL codes: H71, H72, H77.

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*We would like to thank the Editor A. Samwick and an anonymous referee for their helpful comments. M. Besfamille gratefully acknowledges financial support from FONDECYT Grant # 1150170. The usual disclaimer applies.

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1 Introduction

The study of how subnational governments spend intergovernmental transfers has been deeply analyzed by the public finance literature, both theoretically and empirically. One issue that has attracted a lot of attention is the so-called "flypaper effect". This expression illustrates the empirical regularity that subnational governments spend a fraction of a given increase in federal lump-sum transfers that is $\alpha \gg 1$ times larger than the fraction they should have spent if private income were to increase by the same amount.[1] The explanations offered to solve this apparent anomaly are based on (i) flaws in the empirical strategy, like mistakes in the data (when researchers consider to be lump-sum a transfer that is not) or econometric problems (miss-specification, omitted variables, endogeneity), (ii) the fact that subnational governments have to rely on distortionary taxation to fund their expenditures, and (iii) departures from the simple model of a rational government that maximizes the median voter's utility subject to a budget constraint (fiscal illusion, budget-maximizing local bureaucrats, local political competition).[2]

This note provides another theoretical explanation of the flypaper effect, without assuming any departure from the "traditional theory of grants-in-aid" (Bailey and Connolly (1998)) or the use of distortionary taxation at the subnational level. Recognizing the intertemporal and uncertain nature of local private income and intergovernmental transfers, as well as their exogeneity from local fiscal policies, we follow Holtz-Eakin and Rosen (1991) and Holtz-Eakin et al. (1993) incorporating dynamic stochastic features into the conventional framework of local public finances.

Assuming a particular stochastic process for private income and intergovernmental transfers, we solve the local government's intertemporal problem. We adopt a specific functional form for individual utility, which enables us to obtain an expression of the change in optimal public goods provision, in terms of current and previous changes in private income and intergovernmental transfers.[3] In the context of our example, the flypaper effect is not an anomaly, but a natural optimizing behavior. When shocks to intergovernmental transfers are more permanent than those affecting private income, as characterized by the autoregressive coefficients of their respective stochastic process, an increase in intergovernmental transfers increases public goods provision much more than if private income were to increase in an equivalent amount.

[1] In the literature, the magnitude of the flypaper effect α lies between two and ten. See Gramlich (1977) and Gamkhar and Shah (2007).

[2] See Gramlich (1977), Hamilton (1986), Hines and Thaler (1995), Bailey and Connolly (1998), Gamkhar and Shah (2007), Inman (2008) and Dahlby (2011).

[3] In a two-period model, Vegh and Vuletin (2011) obtain that the flypaper effect is an optimal behavior under uncertainty, but its existence depends crucially on an particular assumption regarding the composition of the local public income. Here, we make no assumption regarding this feature of the model.

2 The model

There is a region populated by a continuum of identical residents of mass one. At the beginning of each period, residents earn the same income. The local government maximizes the representative resident's utility, subject to its budget constraint. On the revenue side of the budget, the local government taxes individual income (net of federal taxes) [hereinafter, private income], issues debt, and receives intergovernmental transfers. With these revenues, the local government repays previously contracted debt and provides public goods.

A key ingredient of the model is the information that the local government possesses, with respect to some features of the fiscal policy, when it adopts its decisions. First, the local government considers that *future* private income is not affected by its *current* fiscal policies. This is consistent with the empirical results obtained by Holtz-Eakin et al. (1989). Second, due to institutional design, intergovernmental transfers are lump-sum: they depend neither upon local fiscal policies' outcomes (e.g., tax collection, provision of public goods) nor upon regional characteristics that can be indirectly affected by such policies (e.g., poverty index, tax base, population density). Therefore, the local government treats private income and intergovernmental transfers as exogenous. But it recognizes that both of them are random variables. Having observed the history of their realizations at date s, denoted by z^s, the local government estimates that these variables evolve according to some stochastic process.

We assume that the realizations of private income and intergovernmental transfers occur at the beginning of each period, and also that local fiscal policy can be contingent on these realizations. So, at the end of period t, the local government solves the following problem

$$\max_{\{c_s(z^s),g_s(z^s),T_s(z^s),b_{s+1}(z^s)\}_{s=t}^{\infty}} \mathbb{E}_t \left[\sum_{s=t}^{\infty} \beta^{s-t} U\left(c_s(z^s), g_s(z^s)\right) \right] \tag{1}$$

s.t.

$$c_s(z^s) = y_s(z^s) - T_s(z^s) \qquad \forall s \geq t, \forall z^s \tag{2}$$

$$g_s(z^s) + b_{s+1}(z^s) = T_s(z^s) + \tau_s(z^s) + (1+r)b_s(z^{s-1}) \qquad \forall s \geq t, \forall z^s. \tag{3}$$

If we define by $F(z^s)$ the cumulative distribution function of history z^s, E_t is the expectations operator with respect to this cdf. Expression (1) is the expected present value, discounted at the social rate of time preference β, of the stream of within period utility $U(.)$. We denote by y private income, by c individual consumption, by g the public goods provision, by τ intergovernmental transfers, and by T the per-capita local tax payment. Expression (2) is the representative resident's budget constraint. Assuming an exogenous, constant (both across time and states of nature) interest rate r, we denote by $b_s(z^{s-1})$ provincial assets bought in period $(s-1)$, that pay $(1+r)$ in period s. By the properties of the continuum, expression (3) is the local government's budget constraint.

From (2), we obtain the value of $T_s(z^s)$ and we replace it in (3) to get the following resource constraint of the local government

$$g_s(z^s) + c_s(z^s) + b_{s+1}(z^s) = y_s(z^s) + \tau_s(z^s) + (1+r)b_s(z^{s-1}). \tag{4}$$

The first-order conditions of the local government's problem are[4]

$$\beta^{s-t}U_c\left(c_s(z^s),g_s(z^s)\right)dF(z^s)=\lambda_s(z^s)\qquad \forall s\geq t,\forall z^s \quad FOC(c)$$
$$\beta^{s-t}U_g\left(c_s(z^s),g_s(z^s)\right)dF(z^s)=\lambda_s(z^s)\qquad \forall s\geq t,\forall z^s \quad FOC(g)$$
$$-\lambda_s+\int_{z_{s+1}|z^s}\lambda_{s+1}(z^s,z_{s+1})(1+r)=0\qquad \forall s\geq t,\forall z^s \quad FOC(b)$$

where $\lambda_s(z^s)$ is the Lagrange multiplier associated with the resource constraint (4), and the transversality condition is

$$\lim_{s\to\infty}\mathbb{E}_t\left[\frac{b_s}{(1+r)^{s-t}}\right]=0. \tag{5}$$

To obtain closed-form solutions, we further assume that within-period utility is quadratic

$$U\left(c,g\right)=\left(c-\frac{a}{2}c^2\right)+\left(g-\frac{a\kappa}{2}g^2\right),$$

where a is a positive but a small enough number, so that utility is strictly increasing in a neighborhood of the solution. More important, the preference parameter $\kappa\geq 0$ captures the degree of substitution between c and g. First-order conditions can be rewritten as follows[5]

$$c_s=\kappa g_s \tag{6}$$

$$a\kappa\left(g_s-\beta(1+r)\mathbb{E}_s[g_{s+1}]\right)=1-\beta(1+r). \tag{7}$$

Expression (6) describes the intra-period optimal allocation between consumption and public goods. As expected, the lower is the parameter κ, the lower is the ratio of private consumption to public goods at the optimum. The Euler equation (7) describes the optimal expected change for public goods. If we assume that $\beta(1+r)=1$, we obtain

$$g_s=\mathbb{E}_s(g_{s+1}). \tag{8}$$

Expression (8) suggests that local public good's provision g follows a martingale, a modified version of Hall's (1978) result.

Iterating on (4) and using (5), the intertemporal resource constraint in expectations terms is

$$\mathbb{E}_t\Big[\sum_{s=t}^{\infty}\frac{(c_s+g_s)}{(1+r)^{s-t}}\Big]=\mathbb{E}_t\Big[\sum_{s=t}^{\infty}\frac{(y_s+\tau_s)}{(1+r)^{s-t}}\Big]+(1+r)b_t. \tag{9}$$

Replacing (6) in (9), we get

[4] Subscripts of functions denote partial derivatives.

[5] From now on, we omit the dependence on the history z^s.

$$(1+\kappa)\,\mathbb{E}_t[\sum_{s=t}^{\infty}\frac{g_s}{(1+r)^{s-t}}] = \mathbb{E}_t[\sum_{s=t}^{\infty}\frac{(y_s+\tau_s)}{(1+r)^{s-t}}] + (1+r)b_t. \tag{10}$$

Now, using the law of iterative expectations, the lhs of (10) is

$$(1+\kappa)\,\mathbb{E}_t[\sum_{s=t}^{\infty}\frac{g_s}{(1+r)^{s-t}}] = (1+\kappa)\,g_t\frac{1+r}{r}. \tag{11}$$

Calling the rhs of (10) the expected present value of regional wealth $\mathbb{E}_t(\widetilde{W})$, the optimal public goods provision is

$$g_t^* = \frac{r}{1+r}\frac{1}{1+\kappa}\mathbb{E}_t(\widetilde{W}). \tag{12}$$

Expression (12) is the typical condition derived in intertemporal consumption models, but obtained in the context of local public finances. The optimal provision of public goods is a function of the expected present value of regional wealth $\mathbb{E}_t(\widetilde{W})$, and is proportional to the real interest rate, with the added feature that $\mathbb{E}_t(\widetilde{W})$ has to be allocated between private consumption and public goods, according to the preference parameter κ.

3 The flypaper effect

To present the main result of this note, we consider the following example. Assume that the local government estimates that private income and intergovernmental transfers' first differences evolve according to stationary, second-order autoregressive processes with drifts, as follows[6]

$$\Delta y_t - \gamma = \rho_1(\Delta y_{t-1} - \gamma) + \rho_2(\Delta y_{t-2} - \gamma) + \epsilon_t, \tag{13}$$

$$\Delta \tau_t - \phi = \theta_1(\Delta \tau_{t-1} - \phi) + \theta_2(\Delta \tau_{t-2} - \phi) + \xi_t, \tag{14}$$

where $|\gamma|, |\phi| < r$ and ϵ_t, ξ_t are independent white noise shocks. The magnitude of the autoregressive coefficients ρ_1, ρ_2, θ_1 and θ_2 determine how permanent shocks ϵ_t and ξ_t are, respectively.

Going one step further than Holtz-Eakin et al. (1993), we use (12) and the laws of movement (13)-(14) to obtain an expression for the change of optimal public goods provision Δg_t^* in terms of current and lagged changes in private income and intergovernmental transfers. The following proposition characterizes this change.

Proposition 1 *When the local government estimates that private income and intergovernmental transfers evolve according to (13)-(14), the current change of optimal public goods*

[6] Hereinafter, $\Delta x_{t-s} \equiv x_{t-s} - x_{t-s-1}$, $\forall x, \forall s \in [0, t-1]$

provision is

$$\Delta g_t^* = \frac{(1+r)^2}{(1+\kappa)} \left\{ \frac{1}{D} \left[\Delta y_t - \rho_1 \Delta y_{t-1} - \rho_2 \Delta y_{t-2} - \gamma(1-\rho_1-\rho_2) \right] \right. \\ \left. \frac{1}{M} \left[\Delta \tau_t - \theta_1 \Delta \tau_{t-1} - \theta_2 \Delta \tau_{t-2} - \phi(1-\theta_1-\theta_2) \right] \right\}, \tag{15}$$

where $D \equiv (1+r-\rho_1)(1+r) - \rho_2$ *and* $M \equiv (1+r-\theta_1)(1+r) - \theta_2$.

Despite the fact that the local government chooses g_t^* according to the long-term perceived level of regional wealth, Δg_t^* is completely characterized by variables that are known in period t. In particular, Δg_t^* is determined by how permanent shocks are, as characterized by the value of their corresponding autoregressive parameters.

Now, we use the result presented in Proposition 1 to analyze the flypaper effect. *Ceteris paribus*, the local government's responses to equivalent changes in private income and intergovernmental transfers are

$$\frac{\Delta g_t^*}{\Delta y_t} = \frac{(1+r)^2}{(1+\kappa)\, D}$$

and

$$\frac{\Delta g_t^*}{\Delta \tau_t} = \frac{(1+r)^2}{(1+\kappa)\, M}. \tag{16}$$

As both expressions can be easily compared, the following proposition presents the main result of this note.

Proposition 2 *The flypaper emerges, with a magnitude of* α *(i.e.,* $\frac{\Delta g_t^*}{\Delta \tau_t} \geq \alpha \frac{\Delta g_t^*}{\Delta y_t}$*), if and only if*

$$\frac{1}{\alpha}\left(\rho_1 + \frac{\rho_2}{1+r}\right) - \frac{\alpha-1}{\alpha}(1+r) \leq \theta_1 + \frac{\theta_2}{1+r}. \tag{17}$$

Condition (17) hold under many parameter configurations of the model, and includes all autoregressive coefficients, not only the first ones. Indeed, the complete structure of the dynamic processes matters to explain how important (and different) current responses are. The intuition for this result is straightforward: if shocks affecting intergovernmental transfers are more persistent, and thus generate larger wealth effects, than those affecting private income, facing an equivalent increase in both variables, the change in public goods provision should be α times larger in the former than in the latter case.

4 Conclusion

This note provides a new theoretical explanation of the flypaper effect, without assuming any departure from the traditional theory of grants-in-aid or without incorporating distortionary taxation at the subnational level. In the context of a standard model, where the local authority chooses its fiscal policy to maximize the expected intertemporal utility of the representative resident, subject to a budget constraint composed by different exogenous, random sources of revenue, we present a simple example showing that the flypaper effect can naturally emerge as an optimal local behavior provided there are differences in the stochastic processes governing the time profile of both sources of public revenues. One could generalize this example to consider other stochastic processes or to incorporate other types of intergovernmental grants. Also, one can try to find empirical evidence that the evolution of private income and intergovernmental grants satisfy conditions (13)-(14) and (17). All these are interesting venues for further research.

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5 Appendix

5.1 Proof of Proposition 1

The optimal public goods provision is

$$g_t^* = \frac{r}{1+r}\frac{1}{(1+\kappa)}\mathbb{E}_t(\widetilde{W}).$$

Next, we expand the term $\mathbb{E}_t(\widetilde{W})$. Let's start by the present value of the stream of expected private income. Given that its stochastic process is given by

$$\Delta y_t - \gamma = \rho_1 (\Delta y_{t-1} - \gamma) + \rho_2 (\Delta y_{t-2} - \gamma) + \epsilon_t,$$

obtaining such an expression is not straightforward.

Let's define

$$\Omega_t = \begin{bmatrix} \Delta y_t - \gamma \\ \Delta y_{t-1} - \gamma \end{bmatrix}, \; F = \begin{bmatrix} \rho_1 & \rho_2 \\ 1 & 0 \end{bmatrix} \text{ and } \Xi_t = \begin{bmatrix} \epsilon_t \\ 0 \end{bmatrix},$$

where $\|F\| < 1$ by the stationarity conditions. With these definitions, we rewrite (13) as the following first-order vector difference equation

$$\Omega_{t+1} = F \cdot \Omega_t + \Xi_{t+1}. \tag{18}$$

Applying the same technique as for an AR(1) process, we compute the following inner product to obtain

$$\mathbb{E}_t [\Delta y_{t+s} - \gamma] = \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \mathbb{E}_t [\Omega_{t+s}] = \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot F^s \cdot \Omega_t \tag{19}$$

Using (18), the fact that $\mathbb{E}_t [y_{t+s}]$ can be decomposed as

$$\mathbb{E}_t [y_{t+s}] = y_{t-1} + \sum_{i=0}^{s} \mathbb{E}_t [\Delta y_{t+i} - \gamma] + (s+1)\gamma, \tag{20}$$

and also that the stationarity restrictions enable us to calculate

$$\sum_{i=0}^{s} F^s = \left[I - F^{s+1}\right] \cdot [I - F]^{-1}$$

where I is the identity matrix, we get

$$\mathbb{E}_t\left[y_{t+s}\right] = y_{t-1} + \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \left[I - F^{s+1}\right] \cdot \left[I - F\right]^{-1} \cdot \Omega_t + (s+1)\,\gamma. \tag{21}$$

Using (20), the discounted sum of expected private incomes is

$$\begin{aligned} \textstyle\sum_{s=0}^{\infty} \frac{\mathbb{E}_t\left[y_{t+s}\right]}{(1+r)^s} = \; & y_{t-1}\frac{(1+r)}{r} \\ & + \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \left[\frac{(1+r)}{r} I - \left[\textstyle\sum_{s=0}^{\infty} \frac{F^s}{(1+r)^s}\right] \cdot F\right] \cdot \left[I - F\right]^{-1} \cdot \Omega_t \\ & + \gamma \frac{(1+r)^2}{r^2}. \end{aligned} \tag{22}$$

Assuming that all eigenvalues of the matrix F verify $|\lambda_i| < 1 + r$,[7] we have that

$$\sum_{s=0}^{\infty} \frac{F^s}{(1+r)^s} = \left[I - \frac{F}{(1+r)}\right]^{-1} = \begin{bmatrix} \frac{(1+r)^2}{D} & \frac{\rho_2 (1+r)}{D} \\ \frac{(1+r)}{D} & \frac{(1+r-\rho_1)(1+r)}{D} \end{bmatrix}, \tag{23}$$

where $D = (1 + r - \rho_1)(1 + r) - \rho_2$. Plugging (22) in (21), we obtain

$$\begin{aligned} \textstyle\sum_{s=0}^{\infty} \frac{\mathbb{E}_t\left[y_{t+s}\right]}{(1+r)^s} = \; & \frac{1+r}{r} \left\{ \frac{(1+r)^2}{D} y_t + \frac{r\rho_2 - \rho_1 (1+r)}{D} y_{t-1} \right. \\ & \left. - \frac{\rho_2 (1+r)}{D} y_{t-2} + \gamma \frac{(1+r)^2 (1 - \rho_1 - \rho_2)}{rD} \right\}. \end{aligned} \tag{24}$$

Applying the same method, we obtain the discounted sum of expected intergovernmental transfers

$$\begin{aligned} \textstyle\sum_{s=0}^{\infty} \frac{\mathbb{E}_t\left[\tau_{t+s}\right]}{(1+r)^s} = \; & \frac{1+r}{r} \left\{ \frac{(1+r)^2}{M} \tau_t + \frac{r\theta_2 - \theta_1 (1+r)}{M} \tau_{t-1} \right. \\ & \left. - \frac{\theta_2 (1+r)}{M} \tau_{t-2} + \phi \frac{(1+r)^2 (1 - \theta_1 - \theta_2)}{rM} \right\}, \end{aligned} \tag{25}$$

where $M = (1 + r - \theta_1)(1 + r) - \theta_2$.

Finally, plugging (23) and (24) in (12), we find

$$g_t^* = A_t + \frac{r}{1+K} b_t^*, \tag{26}$$

[7] This is true if the system is covariance stationary.

where

$$
\begin{aligned}
A_t \equiv \; & \frac{1}{(1+\kappa)} \left\{ (1+r)^2 \left[\frac{y_t}{D} + \frac{\tau_t}{M} \right] + \frac{r\rho_2 - \rho_1 (1+r)}{D} y_{t-1} \right. \\
& + \frac{r\theta_2 - \theta_1 (1+r)}{M} \tau_{t-1} - (1+r) \left[\frac{\rho_2}{D} y_{t-2} + \frac{\theta_2}{M} \tau_{t-2} \right] \\
& \left. + \frac{(1+r)^2}{r} \left[\phi \frac{(1-\theta_1-\theta_2)}{M} + \gamma \frac{(1-\rho_1-\rho_2)}{D} \right] \right\}.
\end{aligned} \tag{27}
$$

Replacing g_t^* and c_t in (4), we obtain

$$\Delta b_t^* \equiv b_{t+1}^* - b_t^* = y_t + \tau_t - (1+K)A_t.$$

Advancing (25) one period and substracting it from itself yields

$$\Delta g_{t+1}^* \equiv g_{t+1}^* - g_t^* = A_{t+1} - (1+r)A_t + \frac{r}{1+K}(y_t + \tau_t). \tag{28}$$

Replacing A_{t+1} and A_t in (28), rearranging and lagging one period we finally obtain (15). ■