Unsticking the flypaper effect in an uncertain world*

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Abstract

We provide a novel explanation for the flypaper effect based on portfolio theory/insurance arguments. The model generates two testable implications: (i) the flypaper effect is a decreasing function of the correlation between fiscal transfers and private income, and (ii) such relationship is stronger the higher is the volatility of fiscal transfers and/or private income. Data for Argentinean provinces and Brazilian states supports these hypotheses.

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"The flypaper effect results when a dollar of exogenous grant-in-aid leads to significantly greater public spending than an equivalent dollar of citizen income: Money sticks where it hits. Viewing governments as agents for a representative citizen voter, this empirical result is an anomaly."
Robert Inman (2008)

1 Introduction

The flypaper effect is a widely-documented empirical regularity in public finance that refers to the fact that the propensity of subnational governmental units to spend out of intergovernmental unconditional fiscal transfers (hereafter, fiscal transfers) is higher than the propensity to spend out of private income. According to Inman (2008), 3,500 research papers have documented this stylized fact for numerous countries and levels of government in the world. These studies show that while an extra dollar in private income increases public spending by \$0.02-\$0.05, an equivalent increase in fiscal transfers triggers a rise in spending that lies between \$0.25 and \$1.3. The term "flypaper effect" was coined in early papers that uncovered this stylized fact (Henderson, 1968; Gramlich, 1969). This catchy expression captures the idea that money sticks where it hits: money in the private sector (i.e., from private income) tends to be allocated to private consumption rather than being taxed away, while money in the public sector (i.e., from fiscal transfers) tends to be spent by the public sector rather than being rebated to citizens.

As Inman's quote illustrates, the flypaper effect has been regarded as a puzzle or an anomaly. This is indeed the case if one thinks in terms of a model in which a representative citizen's utility is maximized subject to her total income –composed by the sum of private income and her share of fiscal transfers. Such a model would predict an identical propensity to spend out of citizen's private income or fiscal transfers. After all, money is fungible and the source of financing should not affect the optimal allocation of resources.

Explanations for the flypaper effect have abounded and can be divided into five different groups, two of them pointing to potential specification errors and the remaining three based on theoretical arguments. A first group of explanations argues that non-fungible conditional fiscal transfers, like the ones American states receive from matching grants, are misclassified as unconditional ones. A second group holds that omitted variables could also falsely support the flypaper effect if unobserved community's characteristics, which affect the technology or effective cost of public spending, were systematically related with citizens' private income

(Hamilton, 1983). The flypaper puzzle, however, remains after using truly unconditional grants (Inman, 1971; Gramlich and Galper, 1973; Bowman, 1974) or controlling for population characteristics. A third group holds that the model of citizen fiscal choice might be misspecified because either the citizen confuses the income effect generated by fiscal transfers with a price effect that reduces the average effective cost of public spending (Courant et al, 1979; Oates, 1979), he/she is not fully informed and fails to see the public budget (Filimon et al, 1982) or, even when fully informed, he/she might not behave completely rationally (Hines and Thaler, 1995). A fourth group uses political science arguments that exploit the role that inefficient political institutions have in revealing citizens' preferences (Chernick, 1979; Knight, 2002). A fifth group relies on real collection costs (Hamilton, 1986; Aragón, 2009) or distortionary taxation arguments (Végh and Vuletin, 2011).

This paper shows that, far from being a puzzle, the flypaper effect may be viewed as the natural outcome in an uncertain world with incomplete markets in which a subnational unit (hereafter, province) has two stochastic sources of income: private income and fiscal transfers. In such a world, how will government spending react to an increase in fiscal transfers relative to an increase in private income?[1] We show that the answer depends on (i) how each shock affects the variance of total income (a *differential volatility effect*) and (ii) how precautionary savings react to the change in the variance of total income (a *precautionary savings effect*).

To understand the basic intuition behind our results, consider, as a benchmark, the extreme case in which the variance of private income and fiscal transfers is the same and the correlation is one. In such a case, both sources of income are identical in terms of risk. Since either shock will increase the variance of total income by the same amount (i.e., the differential volatility effect is zero), precautionary savings will increase by the same amount and, therefore, government spending will rise by the same amount in response to either shock. In other words, the flypaper effect is zero. In fact, in this case of perfect positive correlation, our stochastic model reduces to the standard static model with no uncertainty because the stochastic structure is such that fiscal transfers do not provide any insurance.

Suppose now that the correlation between private income and fiscal transfers is zero. In this case, fiscal transfers are providing some insurance to the province because it now has two uncorrelated sources of income. Suppose also that, as is the case in practice, the share of fiscal transfers in total income is less than half (i.e., private income represents the main source of total income). An increase in private income will then raise the variance of total

[1] By increase in either fiscal transfers or private income, we mean an increase in their expected value.

income by more than the same increase in fiscal transfers because an increase in private income raises the share of private income in total income but an equivalent increase in fiscal transfers reduces it. In other words, from a portfolio point of view, an increase in private income decreases diversification, while an increase in fiscal transfers increases it.[2] As a result, precautionary savings will increase by more in the case of an increase in private income than in the case of an increase in fiscal transfers. This implies that overall spending will be higher in response to an increase in fiscal transfers than in response to an increase in private income. Since overall spending is allocated to both private and government consumption, government spending increases by more in response to an increase in fiscal transfers than in response to an increase in private income (i.e., the flypaper effect is positive). In sum, our model can explain a positive flypaper effect simply as the result of the fact that two non-perfectly correlated sources of income affect the variance of total income differently and thus lead to differential reactions of precautionary savings and hence of government spending. The only key friction is the assumption of incomplete markets.

To fix ideas, we have considered the case of zero correlation. But an analogous argument holds for any positive or negative value of ρ as long as it is smaller than one. Figure 1 illustrates this idea by plotting the flypaper effect against ρ. As discussed above, when $\rho = 1$, the flypaper effect is zero (point A). For any other value of ρ, the flypaper is positive. The case of zero correlation would correspond to point B. Furthermore, as the figure shows, the flypaper effect is a decreasing function of ρ. Intuitively, as the correlation increases, the two sources of income become more similar in terms of risk (i.e., insurance falls). As they become more similar, the difference in how precautionary savings react becomes smaller and hence the flypaper effect becomes smaller.

In addition to offering a new theoretical take on the flypaper effect, our model yields two testable empirical implications:

1. The flypaper effect is a decreasing function of the correlation between private income and federal transfers (as already discussed above).[3]

2. The effect of the correlation on the flypaper effect becomes stronger the higher is the

[2] Remember from basic portfolio theory that if a portfolio is comprised of two uncorrelated sources of income with equal variances, the total variance is minimized if each source represents one half of the portfolio. Of course, while in portfolio theory the shares of different assets is chosen optimally, the provinces take as given these shares.

[3] While we have described the basic intuition assuming equal variances, this theoretical implication does not require such an assumption.

volatility of private income and/or transfers. In terms of Figure 1, we can imagine the curve pivoting around point A and shifting outward. Intuitively, the role of ρ on the differential volatility effect and precautionary savings becomes smaller as variances become smaller. If variances are close to zero, the correlation coefficient plays no role and the curve in Figure 1 would almost coincide with the horizontal axis.

We test the two predictions of the model by using two different datasets for Argentinean provinces and Brazilian states. Unlike the American system of intergovernmental transfers that are typically conditional on states' spending in particular areas (mainly health and social programs), Argentinean provinces and Brazilian states mostly rely on a tax-sharing system that is regulated by laws that rarely change. In other words, Argentinean provinces and Brazil states receive fiscal transfers that are, in essence, unconditional and exogenous. We find that the magnitude and sign of the flypaper effect critically depends on (i) the correlation between both sources of income and (ii) their volatilities. For example, for an average Argentinean province, we find that a decrease in the correlation of 0.1 increases the flypaper effect by 0.067 (or about 10 percent of the flypaper effect estimated for Argentina). The equivalent figure for Brazil is 0.072 (or about 7 percent of the flypaper effect estimated for Brazil). Furthermore, if the volatility of output and fiscal transfers were equal to the highest in our sample, these figures would increase almost 40 times for Argentina and 25 times for Brazil.

The paper proceeds as follows. To set the stage for the discussion, Section 2 develops a standard one-period model where the flypaper effect is a puzzle. We then show that the puzzle remains in a two-period model. Section 3 adds uncertainty to our two-period model and shows how, under complete markets, the model still cannot generate a flypaper effect. Finally, we show how the mere presence of uncertainty under incomplete markets can rationalize the flypaper effect. Section 4 briefly describes fiscal federalism in Argentina and Brazil and emphasizes the unconditional and exogenous nature of their fiscal transfers. We then turn to the regression analysis. Section 5 establishes the strong presence of the flypaper effect. We then test our two key empirical implications in Section 6 and find strong support for them. Final thoughts are presented in Section 7.

2 Models with certainty

As a theoretical benchmark, this section presents a standard one-period model that has been traditionally used in this literature to illustrate the flypaper effect as an anomaly. We then add a second period to the model to capture saving dynamics and show how the flypaper puzzle remains.

As is standard in this literature (e.g., Henderson, 1968; Gramlich, 1969; Knight, 2002; Inman, 2008) we set up a maximization problem in which the representative citizen (RC) maximizes her utility subject to her total income, which is the sum of her private income (y) and her share of fiscal transfers (f).[4] In other words, resources are assumed to be fungible.

There is a single and non-storable good which is used as the numeraire. The good can be allocated to either government spending (g) or private consumption (c). We also assume, for simplicity, that initial assets are zero.

For further reference, define the flypaper effect (FP) as

$$FP \equiv \triangle g^f - \triangle g^y, \tag{1}$$

where $\triangle g^y$ and $\triangle g^f$ denote the change in government spending in response to an increase of one dollar in private income or fiscal transfers, respectively. A positive value of FP, which means that $\triangle g^f > \triangle g^y$, would imply that the model can explain the flypaper effect. Conversely, a negative or zero value would imply that the model cannot explain the flypaper effect.

2.1 One period model

The exogenous levels of private income and fiscal transfers are given by y and f, respectively:

$$y = \overline{y} + s_y, \tag{2}$$

$$f = \overline{f} + s_f, \tag{3}$$

where $\overline{y}$ and $\overline{f}$ are initial (i.e., pre-shock) levels of private income and fiscal transfers, respectively, and s_y and s_f denote the private income and fiscal transfer shock, respectively. In order to evaluate the effects of a private income and a fiscal transfer shock, we define an initial equilibrium characterized by $s_y = s_f = 0$. A private income shock consists in an increase in s_y such that $\triangle y = 1$ (i.e., $s_y = 1$), while a fiscal transfer shock consists in an increase in s_f such that $\triangle f = 1$ (i.e., $s_f = 1$).

[4] We think of our economy as a small open economy but, in this one-period version, it is identical to a closed economy.

Let preferences be given by

$$W^1 = u(c) + v(g), \tag{4}$$

where W^1 stands for welfare in the one-period model. For simplicity, we also assume that $u(.)$ and $v(.)$ take the same functional form (i.e., $u(.) = v(.) = h(.)$).

The RC's total income constraint is given by

$$y + f = c + g. \tag{5}$$

The RC chooses c and g to maximize (4) subject to (5). Solving the maximization problem, we obtain[5]

$$c = g = \frac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right). \tag{6}$$

That is to say, since $u(.)$ and $v(.)$ take the same functional form, then $c = g$. Consequently, RC's total income is equaly allocated between c and g.

It follows from (6) that both private income and fiscal transfer shocks generate the same increase in g. Therefore,

$$FP = 0. \tag{7}$$

In sum –and in line with previous theoretical findings (e.g., Henderson, 1968; Gramlich, 1969)– the optimal allocation of resources does not depend on the source of financing. In other words, the propensity to spend on g does not depend on whether additional resources come in the form of private income or fiscal transfers.

2.2 Two-period model

We now develop a two-period model under certainty. This is a small open economy perfectly integrated into world goods and capital markets. To abstract from consumption tilting, we will assume that $\beta = 1/(1+r)$, where $\beta > 0$ is the discount factor and $r > 0$ is the world real interest rate. The exogenous levels of income and fiscal transfers are given by y_1 and f_1 in period 1 and y_2 and f_2 in period 2. We assume, as in Sub-section 2.1, that

$$y_1 = y_2 = \overline{y} + s_y, \tag{8}$$

$$f_1 = f_2 = \overline{f} + s_f. \tag{9}$$

[5] See Appendix 8.2.1 for the derivations.

In a two-period model, a private income shock is defined as a dollar increase in each period's private income (i.e., $\triangle y_1 = \triangle y_2 = s_y = 1$) and a fiscal transfer shock as an equivalent increase in fiscal transfers (i.e., $\triangle f_1 = \triangle f_2 = s_f = 1$).[6]

Preferences are now given by

$$W_C^2 = u(c_1) + v(g_1) + \beta \left[u(c_2) + v(g_2) \right], \tag{10}$$

where W_C^2 stands for welfare in the two-period model with certainty. Again, we assume that $u(c)$ and $v(g)$ take the same functional form.

The RC's intertemporal total income constraint is given by

$$y_1 + f_1 + \frac{y_2 + f_2}{1+r} = c_1 + g_1 + \frac{c_2 + g_2}{1+r}. \tag{11}$$

Equation (11) has the usual interpretation that the present discounted value of private and public spending must equal the present discounted value of private income and fiscal transfers.

The RC chooses c_1, c_2, g_1 and g_2 to maximize (10) subject to (11). Solving the maximization problem, we obtain[7]

$$c_1 = c_2 = g_1 = g_2 = \frac{1}{2} \left(\overline{y} + s_y + \overline{f} + s_f \right). \tag{12}$$

It immediately follows from (12) that both private income and fiscal transfer shocks generate the same increase in g_1 and g_2. Therefore,[8]

$$FP = 0. \tag{13}$$

As in the one-period model, the optimal allocation of resources does not depend on the source of financing. Notice that, given the flat income structure specified in (8) and (9), there are no savings in our model for consumption smoothing motives. It is easy to check, however, that the flypaper effect would be zero even if this were not the case.

[6] In line with the literature on the flypaper effect and, more importantly, in order to have analytical solutions in the case of uncertainty and incomplete markets, we model private income and fiscal transfer shocks as permanent (i.e., they occur in both periods). Our main results would not change if shocks were assumed to be temporary in a multi-period or infinite horizon framework.

[7] See Appendix 8.2.2 for all the derivations.

[8] In this two-period model with no uncertainty, we could define the flypaper effect in both period 1 and 2. When we introduce uncertainty, however, we will define the flypaper effect only in period 1 because that is the only period in which precautionary savings will play a role.

3 Models with uncertainty

This section introduces uncertainty into the two-period model presented in Sub-section 2.2. We first discuss the stochastic structure of income and some basic portfolio theory implications regarding the impact of income shocks on the volatility of total income. We then solve the model assuming complete markets and show that the flypaper puzzle remains. We finally show how, in the presence of incomplete markets, our simple model can rationalize the flypaper effect. The model also generates some key empirical implications that will allow us to take our model to the data.

We assume that there is no uncertainty in the first period; private income and fiscal transfers are given by y_1 and f_1, respectively. Private income and fiscal transfers are uncertain in the second period. Specifically, we assume that

$$y_1 = \overline{y} + s_y, \tag{14}$$

$$y_2 = (\overline{y} + s_y)(1 + \varepsilon_y), \tag{15}$$

$$f_1 = \overline{f} + s_f, \tag{16}$$

$$f_2 = \left(\overline{f} + s_f\right)(1 + \varepsilon_f), \tag{17}$$

where ε_y and ε_f represent mean-preserving spreads of each dollar the RC receives as private income and fiscal transfers, respectively. We assume that $\varepsilon_y \sim N\left(0, \sigma^2_{\varepsilon_y}\right)$, $\varepsilon_f \sim N\left(0, \sigma^2_{\varepsilon_f}\right)$ and that ε_y and ε_f are jointly normally distributed. The parameter ρ is the correlation between ε_y and ε_f. If $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f} = 0$, then the income structure characterized by (14)-(17) would be the same as in Sub-section 2.2.

In this context, we define a private income shock as consisting in an increase in s_y such that $\triangle y_1 = \triangle E[y_2] = 1$ (i.e., $s_y = 1$), while a fiscal transfer shock consists in an increase in s_f such that $\triangle f_1 = \triangle E[f_2] = 1$ (i.e., $s_f = 1$). In other words, second-period private income and fiscal transfers increase, in expected value, by the same amount as they do in the first period. This structure of shocks allows us to keep constant the coefficient of variation before and after the shock.[9] This is a desirable future as it maintains constant the relative volatility of private income and fiscal transfers before and after the shock.

[9] Recall that the coeficient of variation (cv) is defined as $cv \equiv \frac{\text{standard deviation}}{\text{expected value}}$. For our two random variables y_2 and f_2; $cv_{y_2} = \sigma_{\varepsilon_y}$ and $cv_{f_2} = \sigma_{\varepsilon_f}$.

We also assume that

$$\overline{y} = \phi\overline{x}, \tag{18}$$

$$\overline{f} = (1-\phi)\,\overline{x}, \tag{19}$$

where $\overline{x} \equiv \overline{y} + \overline{f}$. Thus, ϕ represents the proportion of initial (i.e., pre-shock) total income corresponding to private income and $1-\phi$ the one corresponding to fiscal transfers. While, in theory, $\phi \in [0,1]$, in practice $1 > \phi > 0.5$. In other words, private income represents the largest fraction of total income.[10] Henceforth, we will assume that $1 > \phi > 0.5$, which is equivalent to assuming that $\overline{y} > \overline{f}$.

Preferences are given by

$$W_U^2 = u(c_1) + v(g_1)$$

$$+\beta \iint p\left(\varepsilon_y, \varepsilon_f\right) \left(u(c_2\left(\varepsilon_y, \varepsilon_f\right)) + v(g_2\left(\varepsilon_y, \varepsilon_f\right))\right) d\varepsilon_y d\varepsilon_f, \tag{20}$$

where $p\left(\varepsilon_y, \varepsilon_f\right)$ is the joint density distribution of ε_y and ε_f and W_U^2 stands for welfare in the two-period model with uncertainty. As in Sub-sections 2.1 and 2.2, we assume that $u(c)$ and $v(g)$ take the same functional form (i.e., $u(.) = v(.) = h(.)$).

3.1 Differential volatility effect

We now derive some stochastic properties of the income portfolio in period 2.[11] Recall that total income in period 2 is given $y_2 + f_2$. Let $\sigma^2_{y_2+f_2}$ denote the variance of total income in period 2. Further, let $\triangle(\sigma^2_{y_2+f_2})^f$ and $\triangle(\sigma^2_{y_2+f_2})^y$ denote the change in $\sigma^2_{y_2+f_2}$ as a result of a fiscal transfer shock and private income shock, respectively. We now define the *differential volatility effect* (DVE) as

$$DVE \equiv \triangle(\sigma^2_{y_2+f_2})^y - \triangle(\sigma^2_{y_2+f_2})^f. \tag{21}$$

The DVE thus captures the different effect that a fiscal transfer shock may have on the variance of total income ($\sigma^2_{y_2+f_2}$) compared to a private income shock.

Taking into account (14)-(19), we can derive the following stochastic properties of the

[10] Fiscal transfers as share of gross subnational product averages 6 percent for Argentinean provinces and 8 percent for Brazilian states. Such figure varies between 2 percent (Buenos Aires) and 15 percent (Formosa) for Argentinean provinces, and 2 percent (Rio Grande do Sul) and 42.5 percent (Roraima) for Brazilian states.

[11] Naturally, this analysis does not apply to period 1 because there is no uncertainty.

income portfolio:

$$\sigma^2_{y2} = (\phi\overline{x} + s_y)^2 \sigma^2_{\varepsilon_y}, \tag{22}$$

$$\sigma^2_{f_2} = [(1-\phi)\overline{x} + s_f]^2 \sigma^2_{\varepsilon_f}, \tag{23}$$

$$\rho_{y_2,f_2} = \rho, \tag{24}$$

$$\sigma^2_{y_2+f_2} = \sigma^2_{y_2} + \sigma^2_{f_2} + 2\rho_{y_2,f_2}\sigma_{y_2}\sigma_{f_2}, \tag{25}$$

where $\sigma^2_{y_2}$ and $\sigma^2_{f_2}$ are the variances of private income and fiscal transfer in period 2, respectively, and ρ_{y_2,f_2} is the correlation between y_2 and f_2. From (22) and (23), it is clear that if, for example, $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f}$, a private income shock (i.e., $s_y = 1$) increases $\sigma^2_{y_2}$ by more than an equivalent fiscal transfer shock (i.e., $s_f = 1$) increases $\sigma^2_{f_2}$. This occurs because $\overline{y} > \overline{f}$ or, alternatively, $1 > \phi > 0.5$. If, in addition, $\rho = 0$, this difference would also imply that $\sigma^2_{y_2+f_2}$ increases by more for a private income shock than for an equivalent fiscal transfer shock (see equation (25)). Hence, from equation (21), $DVE > 0$.

Intuitively, both shocks increase $\sigma^2_{y_2+f_2}$ because the increase in resources available does not occur with certainty, but rather in expected value terms. In other words, the overall risk of the income portfolio increases with each shock. However, while a private income shock increases the relative importance or weight of private income in total income from $\bar{y}/(\bar{y}+\bar{f})$ to $(\bar{y}+1)/(\bar{y}+\bar{f}+1)$, a fiscal transfer shock reduces such weight from $\bar{y}/(\bar{y}+\bar{f})$ to $\bar{y}/(\bar{y}+\bar{f}+1)$. As a result, a fiscal transfer shock increases $\sigma^2_{y_2+f_2}$ by less than a private income shock. In portfolio theory terms, an increase in private income reduces diversification while a rise in fiscal transfers increases it. Moreover, if both shocks are present, diversification increases because the share of private income falls from $\bar{y}/(\bar{y}+\bar{f})$ to $(\bar{y}+1)/(\bar{y}+\bar{f}+2)$ (recall that, by assumption, $\bar{f} < \bar{y}$).

Formally, we can use equations (22)-(25) to compute a reduced-form for $\triangle\left(\sigma^2_{y_2+f_2}\right)^y$ and $\triangle\left(\sigma^2_{y_2+f_2}\right)^f$:

$$\triangle\left(\sigma^2_{y_2+f_2}\right)^y = (1+B)\,\sigma^2_{\varepsilon_y} + \alpha B\sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho, \tag{26}$$

$$\triangle\left(\sigma^2_{y_2+f_2}\right)^f = (1+\alpha B)\sigma^2_{\varepsilon_f} + B\sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho, \tag{27}$$

where $B \equiv 2\phi\overline{x} > 0$ and $\alpha \equiv (1-\phi)/\phi \in (1,0)$ under our maintained assumption that

$1 > \phi > 0.5$ (i.e., $\overline{y} > \overline{f}$). The differential volatility effect is thus given by

$$DVE = (1+B)\,\sigma^2_{\varepsilon_y} - (1+\alpha B)\sigma^2_{\varepsilon_f} - (1-\alpha)B\sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho. \tag{28}$$

This differential effect thus captures the net effect on total income's volatility when both shocks are present. If $DVE > 0$, the private income shock increases total income's volatility by more than the fiscal transfers. The converse is true if $DVE < 0$.

Two important implications follow:

1. The DVE is a decreasing function of ρ. As an intermediate step, notice that, from (26) and (27),

$$\frac{d\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^y\right)}{d\rho} = \alpha\frac{d\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^f\right)}{d\rho} = B\sigma_{\varepsilon_y}\sigma_{\varepsilon_f} > 0. \tag{29}$$

Since $\alpha \in (1,0)$, as ρ decreases (increases), $\sigma^2_{y_2+f_2}$ decreases (increases) by a larger magnitude in response to a fiscal transfer shock than in response to a private income shock. From (28), we obtain

$$\frac{dDVE}{d\rho} = -(1-\alpha)B\sigma_{\varepsilon_y}\sigma_{\varepsilon_f} < 0. \tag{30}$$

Intuitively, as ρ increases, the impact of the fall in the share of private income (i.e., an increase in diversification) decreases because the stochastic structure has become more similar.

2. The effect $dDVE/d\rho$ is, in absolute value, an increasing function of the volatility of $\sigma^2_{\varepsilon_y}$ and/or $\sigma^2_{\varepsilon_f}$. As an intermediate step, notice that, from (29),

$$\frac{d^2\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^y\right)}{d\rho d\sigma_{\varepsilon_f}} = \alpha\frac{d^2\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^f\right)}{d\rho d\sigma_{\varepsilon_f}} = B\sigma_{\varepsilon_y} > 0, \tag{31}$$

$$\frac{d^2\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^y\right)}{d\rho d\sigma_{\varepsilon_y}} = \alpha\frac{d^2\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^f\right)}{d\rho d\sigma_{\varepsilon_y}} = B\sigma_{\varepsilon_f} > 0, \tag{32}$$

$$\frac{d^3\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^y\right)}{d\rho d\sigma_{\varepsilon_y} d\sigma_{\varepsilon_f}} = \alpha\frac{d^3\left(\triangle\left(\sigma^2_{y_2+f_2}\right)^f\right)}{d\rho d\sigma_{\varepsilon_y} d\sigma_{\varepsilon_f}} = B > 0. \tag{33}$$

From (30), we obtain

$$\frac{d^2(DVE)}{d\rho d\sigma_{\varepsilon_f}} = -(1-\alpha)B\sigma_{\varepsilon_y} < 0, \tag{34}$$

$$\frac{d^2(DVE)}{d\rho d\sigma_{\varepsilon_y}} = -(1-\alpha)B\sigma_{\varepsilon_f} < 0, \tag{35}$$

$$\frac{d^3(DVE)}{d\rho d\sigma_{\varepsilon_y}\sigma_{\varepsilon_f}} = -(1-\alpha)B < 0. \tag{36}$$

Intuitively, for a higher volatility, the impact of diversification, and hence DVE, decrease as ρ increases.

Having characterized the properties of the income portfolio, we now turn to the optimization problem faced by the RC first under complete markets and then under incomplete markets.

3.2 Complete markets case

The RC's intertemporal total income constraint takes the form[12]

$$y_1 + f_1 + \frac{1}{1+r}\iint q(\varepsilon_y, \varepsilon_f)(y_2(\varepsilon_y) + f_2(\varepsilon_f))\, d\varepsilon_y d\varepsilon_f$$

$$= (g_1 + c_1) + \frac{1}{1+r}\iint q(\varepsilon_y, \varepsilon_f)(c_2(\varepsilon_y, \varepsilon_f) + g_2(\varepsilon_y, \varepsilon_f))\, d\varepsilon_y d\varepsilon_f, \tag{37}$$

where $q(\varepsilon_y, \varepsilon_f)$ is the price of the contingent asset that promises to pay one unit of output in each state of nature determined by the realization of ε_y and ε_f.

The RC maximizes (20) by choosing c_1, $c_2(\varepsilon_y, \varepsilon_f)$, g_1, and $g_2(\varepsilon_y, \varepsilon_f)$ subject to the constraint (37) and the fair insurance condition $q(\varepsilon_y, \varepsilon_f) = p(\varepsilon_y, \varepsilon_f)$. Solving the model, we obtain[13]

$$c_1 = c_2 = g_1 = g_2 = \frac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right), \tag{38}$$

which coincides with (12) from Sub-section 2.2. From expression (38), it is clear that shocks to either private income or fiscal transfers generate the same increase in both c_1 and g_1. Therefore,

$$FP = 0. \tag{39}$$

[12] As usual, we omit giving the RC a risk free bond since it would be redundant.

[13] See derivations in Appendix 8.2.3.

As in the one-period model (Sub-section 2.1) or the two-period model with certainty (Sub-section 2.2), the optimal allocation of resources does not depend on the source of financing. This occurs because complete markets allow the RC to fully insure herself against all possible contingencies in period 2. Naturally, the presence of complete markets implies no precautionary savings.

3.3 Incomplete markets case

In this section we assume that $h(.)$ is given by a constant absolute risk aversion (CARA) function:

$$h(x) = -e^{-x}. \tag{40}$$

The CARA function has two key properties in the presence of uncertainty and incomplete markets. First, it belongs to a family of utility functions for which the third derivative is positive; this property is key to obtaining precautionary savings. Second, it will also allow us to obtain reduced-form solutions.

The RC's intertemporal total income constraint for each possible realization of ε_y and ε_f takes the form

$$y_1 + f_1 + \frac{y_2(\varepsilon_y) + f_2(\varepsilon_f)}{1+r} = (g_1 + c_1) + \frac{c_2(\varepsilon_y, \varepsilon_f) + g_2(\varepsilon_y, \varepsilon_f)}{1+r}. \tag{41}$$

The RC chooses c_1, $c_2(\varepsilon_y, \varepsilon_f)$, g_1, and $g_2(\varepsilon_y, \varepsilon_f)$ to maximize (20) subject to constraint (41). Solving the model, we obtain[14]

$$\begin{aligned}
c_1 &= g_1 = \frac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right) - \frac{1}{2}PS, & (42)\\
E[c_2] &= E[g_2] = \frac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right) + (1+r)\frac{1}{2}PS, & (43)\\
PS &= A\sigma^2_{y_2+f_2}, & (44)
\end{aligned}$$

where $A \equiv 1/(4(2+r)) > 0$ and PS stands for precautionary savings.[15]

Expressions (42) and (43) are similar to (12) from Sub-section 2.2, and (38) from Sub-section 3.2 in that, as we would expect, part of the resources allocated to consumption and

[14] See derivations in Appendix 8.2.4.

[15] It is important to recall that given the flat structure of initial (i.e., pre-shock) income characterized by (14)-(17), there is no consumption smoothing motives. Consequently, savings equal precautionary savings. However, if this were not the case, it is easy to check that the overall savings could be negative (i.e., deficit) in spite of positive precautionary savings.

government spending depend upon the resources available. This is captured by the first term on the right-most side of expressions (42) and (43). As in all the previous models above, this typical income effect is incapable of explaining the flypaper effect. However, as captured by the second term on the right-most side of expressions (42) and (43), consumption and government spending also depend on precautionary savings. If $PS = 0$, then the incomplete markets solution would coincide with the certainty case and the uncertain case with complete markets. If $PS > 0$ ($PS < 0$), the consumption and government spending in period 1 would be smaller (bigger) than the ones for period 2, measured in expected value terms.

Equation (44) makes clear that, as one would expect, PS is a monotonically increasing function of $\sigma^2_{y_2+f_2}$. That is to say,

$$\triangle PS^f = A\triangle\left(\sigma^2_{y_2+f_2}\right)^f, \tag{45}$$

$$\triangle PS^y = A\triangle\left(\sigma^2_{y_2+f_2}\right)^y, \tag{46}$$

where $\triangle PS^f$ and $\triangle PS^y$ denote the change in precautionary savings that results from a shock to fiscal transfers and private income, respectively. Hence, all the discussion in Sub-section 3.1 on the implications of private income and fiscal transfer shocks on $\sigma^2_{y_2+f_2}$ remains valid for PS.

3.3.1 Flypaper effect

Using (22)-(25) and (42), we obtain[16]

$$\triangle g_1^f = \tfrac{1}{2} - \tfrac{1}{2}\triangle PS^f, \tag{47}$$

$$\triangle g_1^y = \tfrac{1}{2} - \tfrac{1}{2}\triangle PS^y. \tag{48}$$

The first term on the RHS of expressions (47) and (48) captures the typical income effect according to which part of the newly available resources are allocated to government spending. The second term shows that any difference regarding the optimal response of government spending to private income and fiscal transfer shocks must be the result of a different response of precautionary savings to those shocks. In particular, a positive flypaper is associated with a situation in which $\triangle PS^f < \triangle PS^y$, which would occur if $\triangle\left(\sigma^2_{y_2+f_2}\right)^y > \triangle\left(\sigma^2_{y_2+f_2}\right)^f$ (i.e., if $DVE > 0$). The converse is true if $DVE < 0$.

[16] See derivations in Appendix 8.2.4.

Using (45)-(46) and (47)-(48) we can derive the following reduced-form expression for the flypaper effect[17]

$$FP = \frac{1}{2} A \left[(1+B)\, \sigma^2_{\varepsilon_y} - (1+\alpha B)\, \sigma^2_{\varepsilon_f} - B\,(1-\alpha)\, \sigma_{\varepsilon_y} \sigma_{\varepsilon_f} \rho \right]. \tag{49}$$

To fix ideas, let us discuss some particular cases regarding the stochastic structure of incomes which are instructive in clarifying the role of precautionary savings and portfolio theory arguments on the size and sign of the flypaper effect.

1. If $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f} = 0$, then $FP = 0$. This case coincides with the certainty case of Sub-section 2.2.

2. If $\sigma^2_{\varepsilon_y} > 0$, $\sigma^2_{\varepsilon f} = 0$ and, naturally, $\rho = 0$, then $FP = (1/2)\, A\,(1+B)\, \sigma^2_{\varepsilon_y} > 0$. Since private income is risky while fiscal transfers are not, a private income shock increase $\sigma^2_{y_2+f_2}$ and, hence, precautionary savings. A fiscal transfer shock, in contrast, generates no precautionary savings and hence leaves more resources available for spending. As a result, government spending increases more in the case of a fiscal transfer shock (i.e., the flypaper effect is positive).

3. If $\sigma^2_{\varepsilon_y} = 0$, $\sigma^2_{\varepsilon f} > 0$ and, naturally, $\rho = 0$, then $FP = -\,(1/2)\, A\,(1+\alpha B)\, \sigma^2_{\varepsilon_f} < 0$. Since only fiscal transfers are risky, the intuition is analogous to case 2 and the private income shock leaves more resources available for spending. Hence, we obtain an "anti-flypaper" effect.

4. If $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f} > 0$ and $\rho = 1$, then $FP = 0$. Each source of income is equally risky and, because $\rho = 1$, each shock increases $\sigma^2_{y_2+f_2}$ and, hence, PS by the same amount. Each shock thus leads to the same change in government spending, which implies a zero flypaper effect. (This case corresponds to point A in Figure 1.)

5. If $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f} > 0$ and $\rho = 0$, then $FP = (1/2)\, A(1-\alpha)\sigma^2_{\varepsilon_y} B > 0$ because $1 > \alpha > 0$. Each source of income is equally risky. The fact that fiscal transfers represent only a fraction of private income (i.e., $1 > \alpha > 0$) implies that a private income shock increases $\sigma^2_{y_2+f_2}$ by more than a fiscal transfer shock. A fiscal transfer shock thus leaves more resources available for spending, which leads to a positive flypaper effect. (This case corresponds to point B in Figure 1.)

[17] See derivations in Appendix 8.2.4.

6. If $\sigma^2_{\varepsilon_y} = \sigma^2_{\varepsilon_f} > 0$ and $\rho = -1$, then $FP = A(1-\alpha)\sigma^2_{\varepsilon_y} B > 0$ because $1 > \alpha > 0$. This case, which corresponds to point C in Figure 1, is where the flypaper reaches its highest value (for the equal variance scenario). In fact, the flypaper at point C is twice as large as in point B. Intuitively, since $\rho = -1$, the income portfolio achieves its maximum diversification and, hence, the DVE becomes the largest.

From case 3 it is clear that the flypaper effect could, in principle, be negative. Similarly, when positive, the FP is not constrained to be between zero and one. If the model were static, clearly the increase in government spending could not be higher that the increase in resources. However, the dynamic nature of our model allows the use of resources previously allocated to precautionary savings. If the insurance offered by a fiscal transfer shock were sufficiently important, the increase in government spending could, in principle, be bigger than one.

How does the flypaper effect respond to changes in ρ?[18] From (47) and (48),

$$\frac{d\left(\triangle g_1^y\right)}{d\rho} = \alpha \frac{d\left(\triangle g_1^f\right)}{d\rho} = -\alpha \frac{1}{2} AB \sigma_{\varepsilon_y} \sigma_{\varepsilon_f} < 0. \tag{50}$$

From (49),we obtain

$$\frac{dFP}{d\rho} = -\frac{1}{2} AB\left(1-\alpha\right) \sigma_{\varepsilon_y} \sigma_{\varepsilon_f} < 0. \tag{51}$$

As illustrated in Figure 1 (for the equal-variance case), the flypaper effect is a decreasing function of ρ. This is a direct result of the fact that, as discussed above, DVE – and hence precautionary savings – is a decreasing function of ρ.

3.3.2 Theoretical implications

In addition to providing a novel theoretical explanation for the flypaper effect, our model provides two key empirical implications:

1. The flypaper effect is a decreasing function of the correlation between private income and fiscal transfers. This result, already discussed above, is clearly testable.

2. The relationship described in 1 above is stronger the higher is the volatility of private income and/or fiscal transfers. This follows directly from the discussion on the DVE in

[18] As can be easily checked, and for reasons that follow from the above discussion, the effects of σ_{ε_y} and σ_{ε_f} on the flypaper effect are ambiguous and hence do not offer a refutable empirical implication.

Sub-section 3.1. From (50),

$$\frac{d^2(\triangle g_1^y)}{d\rho d\sigma_{\varepsilon_f}} = \alpha \frac{d^2(\triangle g_1^f)}{d\rho d\sigma_{\varepsilon_f}} = -\alpha \tfrac{1}{2} AB\sigma_{\varepsilon_y} < 0, \tag{52}$$

$$\frac{d^2(\triangle g_1^y)}{d\rho d\sigma_{\varepsilon_y}} = \alpha \frac{d^2(\triangle g_1^f)}{d\rho d\sigma_{\varepsilon_y}} = -\alpha \tfrac{1}{2} AB\sigma_{\varepsilon_f} < 0, \tag{53}$$

$$\frac{d^3(\triangle g_1^y)}{d\rho d\sigma_{\varepsilon_y} d\sigma_{\varepsilon_f}} = \alpha \frac{d^3(\triangle g_1^f)}{d\rho d\sigma_{\varepsilon_y} d\sigma_{\varepsilon_f}} = -\alpha \tfrac{1}{2} AB < 0. \tag{54}$$

Hence, from (51), we obtain

$$\frac{d^2(FP)}{d\rho d\sigma_{\varepsilon_f}} = -\tfrac{1}{2} AB\,(1-\alpha)\,\sigma_{\varepsilon_y} < 0, \tag{55}$$

$$\frac{d^2(FP)}{d\rho d\sigma_{\varepsilon_y}} = -\tfrac{1}{2} AB\,(1-\alpha)\,\sigma_{\varepsilon_f} < 0, \tag{56}$$

$$\frac{d^3(FP)}{d\rho d\sigma_{\varepsilon_y} d\sigma_{\varepsilon_f}} = -\tfrac{1}{2} AB\,(1-\alpha) < 0. \tag{57}$$

Equation (55) thus says that the effect described in 1 above becomes stronger (i.e., more negative) if the variance of fiscal transfers increases. The same is true for an increase in the variance of private income –equation (56)– and for an increase in both variances –equation (54).

Having derived our empirical implications, we now proceed to the empirical analysis.

4 Fiscal federalism in Argentina and Brazil

In order to test the two key implications of our theoretical model we use subnational output, total spending, and tax-sharing based fiscal transfers data corresponding to Argentinean provinces and Brazilian states for the period 1963-2006 and 1985-2005, respectively. These datasets are perfectly balanced. There are many extensive descriptions of the specific fiscal federalism arrangements in Argentina and Brazil.[19] Hence, we just provide a brief account and instead focus on characterizing two key features which are useful for our purposes; namely, the unconditional and exogenous nature of federal transfers to provinces/states.

Argentina and Brazil are both federal republics. Argentina is a federation of 23 provinces and an autonomous city, Buenos Aires. Brazil comprises 26 states and a federal district. The size of the government, measured by the ratio of government expenditure to GDP, averages

[19] See for example, Núñez Miñana (1998), Gomez Sabaini and Gaggero (1997), Tommasi et al (2001), Porto (2004), Végh and Vuletin (2011) for Argentina, and Ter-Minassian (1997), Afonso and Mello (2000), and Sturzenegger and Werneck (2006) for Brazil.

35 percent for Argentina and 45 percent for Brazil. Both countries have highly decentralized government spending. On average, Argentinean provinces and Brazilian states are responsible for about 40 percent of overall fiscal spending. On the other hand, tax collection is highly centralized at the federal level. This implies a particularly high vertical imbalance measured as the ratio of intergovernmental fiscal transfers to subnational expenditure, which averages 40 percent (column 2, Tables 1 and 2).

The cornerstone of their intergovernmental fiscal transfer system is a tax-sharing arrangement whereby the federal government transfers to provinces/states some share of federal tax revenues. Indeed, this source of transfers represent (as a percentage of total federal transfers) about 70 percent for Argentinean provinces and more than 60 percent for Brazilian states.

While Argentina and Brazil differ in the specifics regarding the mechanisms of the intergovernmental fiscal transfers, both tax-sharing systems share two key features that prove to be particularly useful for our study. First, they are constitutionally (in Brazil) or law (in Argentina) mandated, rather than discretionary. In essence, these laws regulate how shared tax collection (which includes most domestic taxes, such as VAT and income taxes) is distributed between the central government and provinces/states (which is referred as primary distribution) and how provincial/state funds are distributed between provinces/states (which is referred as secondary distribution). These transfers are unconditional in the sense that, by constitution/law, provinces/states are entitled to them based on their mere existence. This is in sharp contrast to the American federal fiscal system which mainly relies on the federal government sharing with states the cost of some selected programs such as Medicaid, Food Stamp Program, State Children's Health Insurance Program expenditures, Temporary Assistance for Needy Families Contingency Funds, the Federal share of Child Support Enforcement collections, and Child Care Mandatory and Matching Funds of the Child Care and Development Fund.[20] By design, then, American federal transfers are conditional and endogenous to current state spending on those particular programs.

Second, Argentinean and Brazilian tax-sharing systems are characterized by institutional rigidity. The primary and secondary distributions rarely change. For example, the secondary distribution shares for Argentinean provincial governments has changed only four times since 1963 and changes have been minor (Table 3).[21] Indeed, the within province's secondary

[20] Medicaid alone represented around 45 percent of total federal transfers to states and local governments in 2008.

[21] Province's/state's historical secondary distribution shares reflect both contribution to the federal coffers as well as redistributive considerations.

distribution shares variability represent less than one percent of overall variability. Given the intrinsic unconditional and rigid nature of the Argentinean and Brazilian tax-sharing systems, fiscal transfers are, in essence, unconditional and exogenous; a critical property assumed in our theoretical models of Sections 2 and 3.

We should note that – conveniently for identification purposes – the correlation between the cyclical components of output and fiscal transfers varies considerably both *between* and *within* provinces/states. Using a 10-year rolling window, the median correlation varies between -0.39 and 0.69 for Argentinean provinces and -0.52 and 0.74 for Brazilian states. Such correlations average 0.19 and 0.02 for Argentinean provinces and Brazilian states, respectively. The within variability is also quite pronounced for most provinces/states, ranging from negative to positive values.

5 Flypaper effect. Benchmark results

This section shows our benchmark results which confirm that the flypaper effect is clearly present in both federations. We also show how this phenomenon varies significantly across subnational units and over time. Tables 4 and 5 show the basic flypaper regressions for Argentinean provinces and Brazilian states, respectively. We consider the following specification:

$$g_{it} = \alpha_0 + \beta_y y_{it} + \beta_f f_{it} + \textstyle\sum_h \beta_h x_{it}^h + \varepsilon_{it}, \tag{58}$$

where g, y and f represent government spending, output, and fiscal transfers, respectively, all expressed in real and per capita terms.[22] We use x to denote additional control variables. Columns 1 in Tables 4 and 5 show basic OLS regressions without controls and assuming that the residuals are homoscedastic and uncorrelated. For both federations, the marginal propensity to spend out of fiscal transfers is clearly bigger than for local output; i.e., there is a flypaper effect. The regressions in column 2 relax the assumption of homoscedasticity by calculating robust variances and columns 3 relax the assumption of independence within groups by allowing the presence of error autocorrelation within subnational units. It is no surprise that these modifications increase the standard errors. However, the statistical significance of the flypaper effect remains strong.

[22] Optimally we would like to have measures of gross national product as opposed to gross domestic product for each subnational unit. Unfortunately, since there is no such data for subnational units we use gross domestic product. We could proxy gross national product at the subnational level by substracting fiscal transfers from gross domestic product. All our results remain valid.

Like other papers in the literature, columns 4, 5 and 6 include, respectively, several geographic, demographic and political economy control variables including terrain roughness, share of water bodies, population density, and pre-electoral periods. In the Argentinean case, provinces with higher terrain roughness and share of water bodies have higher government spending per capita. Arguably, these features increase the cost of providing public goods. Pre-electoral periods are associated with higher government spending in Argentina and Brazil. Since there might be other unobservable factors that affect government spending, columns 7 also control for subnational units' fixed effect. This helps in controlling for omitted unobservable factors that are constant over time. In columns 8, we also include year dummies to reduce the omitted variable bias that may occur as a consequence of the processes of centralization and decentralization that might have affected these economies during the long periods analyzed (44 years for Argentinean provinces and 21 years for Brazilian states). Even after controlling for all these factors, the flypaper effect remains a strong empirical regularity in all three countries. Specifically, the size of the flypaper effect is 0.69 for Argentinean provinces and 0.99 for Brazilian states. Moreover, in no country can we reject that the size of the flypaper effect equals 1.[23]

While the flypaper effect is clearly a robust phenomenon, it also shows a great deal of variability both across subnational units and over time. For example, Figures 2 and 3 show the size of the flypaper effect when calculated for each subnational unit separately. While the average size of the flypaper effect is close to the ones discussed above, its size ranges between -0.81 and 1.30 for Argentinean provinces and -0.23 and 3.05 for Brazilian states. Furthermore, these figures also vary substantially when evaluated for different periods. Figure 4 shows that the size of the flypaper effect varies between 0.26 and 0.97 for Argentinean provinces and 0.53 and 1.08 for Brazilian states.

6 Flypaper effect. Insurance arguments

Our first empirical implication states that the flypaper effect is a decreasing function of the correlation between private income and fiscal transfers (equation (51)). This occurs because $d(\triangle g_1^f)/d\rho < d\left(\triangle g_1^y\right)/d\rho < 0$ (equation (50)). Moreover, our second empirical implication indicates that such relationship becomes stronger the higher is the volatility of private income

[23] We cannot reject the null hypothesis that the size of the flypaper effect equals 1 for Argentinean provinces (p-value 0.3711) and Brazilian states (p-value 0.7847).

and/or fiscal transfers (equations (55-57)). To test such implications, we add to the basic regression – given by (58) – additional terms that identify the interaction of output and fiscal transfer shocks with the correlation between output and fiscal transfers as well as with their volatilities:

$$\begin{aligned} g_{it} &= \alpha_0 + \beta_y y_{it} + \beta_f f_{it} + \textstyle\sum_h \beta_h x_{it}^h + \\ &+\alpha_1 \rho_{it} + \alpha_2(\rho_{it} \cdot y_{it}) + \alpha_3(\rho_{it} \cdot f_{it}) + \\ &+\alpha_4 \sigma_{y_{it}}^2 + \alpha_5(\sigma_{y_{it}}^2 \cdot y_{it}) + \alpha_6(\sigma_{y_{it}}^2 \cdot f_{it}) + \\ &+\alpha_7 \sigma_{f_{it}}^2 + \alpha_8(\sigma_{f_{it}}^2 \cdot y_{it}) + \alpha_9(\sigma_{f_{it}}^2 \cdot f_{it}) + \\ &+\alpha_{10}(\sigma_{y_{it}}^2 \cdot \rho_{it}) + \alpha_{11}(\sigma_{y_{it}}^2 \cdot \rho_{it} \cdot y_{it}) + \alpha_{12}(\sigma_{y_{it}}^2 \cdot \rho_{it} \cdot f_{it}) + \\ &+\alpha_{13}(\sigma_{f_{it}}^2 \cdot \rho_{it}) + \alpha_{14}(\sigma_{f_{it}}^2 \cdot \rho_{it} \cdot y_{it}) + \alpha_{15}(\sigma_{f_{it}}^2 \cdot \rho_{it} \cdot f_{it}) + \\ &+\alpha_{16}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2) + \alpha_{17}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2 \cdot y_{it}) + \alpha_{18}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2 \cdot f_{it}) + \\ &+\alpha_{19}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2 \cdot \rho_{it}) + \alpha_{20}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2 \cdot \rho_{it} \cdot y_{it}) \\ &+\alpha_{21}(\sigma_{y_{it}}^2 \cdot \sigma_{f_{it}}^2 \cdot \rho_{it} \cdot f_{it}) + \varepsilon_{it}, \end{aligned} \tag{59}$$

where σ_y^2, σ_f^2 and ρ represent the 10 year rolling-window variance of output, fiscal transfers, and correlation between output and fiscal transfers for each subnational unit.

Table 6 shows these regression results for Argentinean provinces and Brazilian states. Based on the theoretical model developed in Sub-section 3.3, the coefficients α_2, α_3, α_{11}, α_{12}, α_{14}, α_{15}, α_{20} and α_{21} are expected to be negative and the rest of the coefficients could be positive or negative. These expected signs are summarized in the last column of Table 6. We also expect that:

1. $|\alpha_3| > |\alpha_2|$ as a result of the first theoretical implication (equations (50) and (51)).

2. $|\alpha_{12}| > |\alpha_{11}|$, $|\alpha_{15}| > |\alpha_{14}|$, and $|\alpha_{21}| > |\alpha_{20}|$ as a result of the second theoretical implication (equations (52)-(57)).

Table 6 supports our first two empirical implications for Argentina and Brazil. Most coefficients – and, in particular, those that interact ρ with σ_y^2 and σ_f^2 – have the expected signs. Furthermore, and as predicted by our model, the coefficients associated with fiscal transfers tend to be higher in absolute value than those associated with output. While α_{15} is positive for Brazil and α_{12} and α_{15} are positive for Argentina, this occurs because of multicollinearity. For Argentinean provinces, the correlation between $\sigma_y^2 \cdot \rho \cdot f$ and $\sigma_y^2 \cdot \sigma_f^2 \cdot \rho \cdot f$

equals 0.82 and the one between $\sigma_f^2 \cdot \rho \cdot f$ and $\sigma_y^2 \cdot \sigma_f^2 \cdot \rho \cdot f$ is 0.66. Similarly, the correlation between $\sigma_f^2 \cdot \rho \cdot f$ and $\sigma_y^2 \cdot \sigma_f^2 \cdot \rho \cdot f$ equals 0.87 for Brazilian states. Moreover, as shown in columns 2, 3, 5 and 6 in Table 7, if the interaction terms between σ_f^2 and ρ, and σ_y^2 and ρ were introduced one at a time, then α_{12} and α_{15} become negative for Argentina and the significance of α_{15} almost disappears for Brazil.

In addition to standard regression output, Table 6 presents computations of the flypaper effect evaluated at different points (i.e., for different values of σ_y^2, σ_f^2 and ρ). These computations give us an alternative way of testing our two empirical implications. To this effect, we consider three scenarios. Specifically, we use the data points with the highest observed values of σ_y^2 and σ_f^2 together with the lowest and highest observed values of ρ. We denote these extreme cases by $FP(\max \sigma_y^2, \max \sigma_f^2, \max \rho)$ and $FP(\max \sigma_y^2, \max \sigma_f^2, \min \rho)$, respectively. These two extreme scenarios will prove to be useful in testing our first empirical implication. Given our theoretical model, we should expect the size of the flypaper to decrease with ρ, especially when σ_y^2 and σ_f^2 are high. We also calculate the size of the flypaper for the minimum values of σ_y^2, σ_f^2 and ρ, which we denote by $FP(\min \sigma_y^2, \min \sigma_f^2, \min \rho)$. We compare the latter measure with $FP(\max \sigma_y^2, \max \sigma_f^2, \min \rho)$ to test our second empirical implication. Given our theoretical model, we should expect the size of the flypaper to be higher for $FP(\max \sigma_y^2, \max \sigma_f^2, \min \rho)$ than for $FP(\min \sigma_y^2, \min \sigma_f^2, \min \rho)$.

As expected, these estimates lead to a large estimated flypaper effect when ρ is negative. For the low (i.e., negative) levels of ρ, the flypaper effect for Argentinean provinces and Brazilian states reaches 36.8 and 21.03, respectively. These figures are much larger than typical estimates of the flypaper effect, which is close to unity, and illustrate the idea that fiscal transfers shocks can actually free more resources from precautionary savings than private income shocks because they provide insurance. On the other hand, for high (i.e., positive) levels of ρ, Argentinean provinces and Brazilian states estimates show that the flypaper effect vanishes. These findings strongly support our first empirical implication. We also find that, given low values of ρ, the size of the flypaper effect is much smaller when variances are low. In particular, the flypaper effect equals 1.28 both for Argentina and Brazil. These findings strongly support our second empirical implication.

Columns 1 and 4 in Table 7 show the result of estimating a regression which only includes the interactions with ρ for Argentinean provinces and Brazilian states, respectively. While the interaction terms α_2 and α_3 tend to be negative, they are statistically insignificant. Far from weakening our theoretical arguments, these results actually strengthen them because they imply that only when all dimensions are involved (i.e., σ_y^2, σ_f^2 and ρ), the correlation, ρ, becomes relevant. In other words, our findings are not likely to be driven by competing theories that may only involved ρ. For example, if subnational units faced binding financial constraints in accessing capital markets – especially during recessions – it would be easy to show that the flypaper effect would be more sizeable during recessions because fiscal transfers would provide subnational units with funds to be used during those periods. The fact that the role of ρ becomes significant only when σ_y^2 and/or σ_f^2 are introduced strongly suggests that our arguments are actually driving the results.

7 Conclusions

This paper has offered a new theoretical explanation for the existence of the flypaper effect. In our view of the world, subnational units have two uncertain sources of income: private income and fiscal transfers. As long as the correlation between the two is not one (and assuming that, as is the case in practice, fiscal transfers are less private income), an increase in fiscal transfers will raise the variance of total income by less than an increase in private income. As a result, the amount of additional precautionary savings is lower in response to the increase in fiscal transfers and the increase in public spending correspondingly higher. The only friction needed for our results to go through is incomplete markets. If market were complete, the flypaper effect would vanish. Since nobody would argue that financial markets are complete in practice, especially in the developing world, our model provides an extremely plausible explanation for the flypaper effect puzzle. In addition, the theoretical model yields two testable empirical implications: (i) the flypaper effect should be a decreasing function of the correlation between fiscal transfers and private income, and (ii) such relationship should become stronger the higher is the volatility of transfers and/or private income. We show that these hypotheses hold for a sample of Argentinean provinces and Brazilian states.

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8 Appendices

8.1 Data

8.1.1 Geographic and demographic data

Terrain roughness equals (surface area/planar area)*100-100. The original dataset used to compute both planar and surface areas was provided by Environmental Systems Research Institute (ESRI). It consists of Global Digital Elevation Model acquired from the NASA/NGA Shuttle Radar Topography Mission (SRTM). The resolution is 3 arc seconds (or approximately 90 meters). The planar area (area as seen from above the earth surface) was computed from the aforementioned SRTM dataset. A "true" surface area (i.e., one where the surfaces along the slopes are accounted for) was calculated from the SRTM dataset by first computing the slope for each pixel, then multiplying the secant (reciprocal of the cosine) of the slope and multiplying this value by the planar area.

Water bodies represents the percentage of surface area covered with water bodies. The data is also from the Environmental Systems Research Institute (ESRI).

Population density is calculated as population/planar area.

8.1.2 Argentinean provinces

Original sources and definition of variables

Total expenditure and fiscal transfers from federal government data for the period 1963-2000 is from Porto (2004) and from Dirección Nacional de Coordinación con las Provincias (Ministry of Economy, Argentina) for the period 2001-2006. Argentinean provinces do not receive intergovernmental transfers from municipalities.

Gross subnational product data for the period 1963-2000 is from Porto (2004) and from Ministry of Economy, Argentina for the period 2001-2006.

CPI data is from IMF/WEO.

Population data for the period 1963-2000 is from Porto (2004) and from Instituto Nacional de Estadística y Censos (Ministry of Economy, Argentina) for the period 2001-2006.

Elections is a dummy variable that equals one the previous and current year of governor election. Electoral data is from Atlas Electoral de Andy Tow and historical newspapers articles.

Online Sources

Porto, Alberto, 2004. Disparidades Regionales y Federalismo Fiscal. EDULP, Argentina. http://www.depeco.econo.unlp.edu.ar

Direccion Nacional de Coordinacion con las Provincias (Ministry of Economy, Argentina). http://www.mecon.gov.ar/hacienda/dncfp/index.html

Instituto Nacional de Estadística y Censos (Ministry of Economy, Argentina). http://www.indec.mecon.ar

Tow, Andy, 2003. Atlas de elecciones en Argentina. http://towsa.com/andy

8.1.3 Brazilian states

Original sources and definition of variables

Total expenditure, fiscal transfers from federal government, population and gross subnational product and its deflator for the period 1985-2005 is from Institute of Applied Economical Research (Ministry of Strategic Issues, Brazil).

Elections is a dummy variable that equals one the previous and current year of governor election. Electoral data is also from Institute of Applied Economical Research (Ministry of Strategic Issues, Brazil).

Online Sources

Institute of Applied Economical Research (Ministry of Strategic Issues, Brazil).
http://www.ipeadata.gov.br

8.1.4 Correlation and variances calculations

σ_y^2, σ_f^2 and ρ represent the 10 year rolling-window variance of output, federal transfers and correlation between output and federal transfers for each subnational unit. More precisely, σ_y^2, σ_f^2 are calculated as follows

$$\begin{aligned} &\sigma^2_{h_{i,t}} = \tfrac{1}{10}\textstyle\sum_{j=0}^{9}\left(h_{i,t-j} - \overline{h}_{it}\right)^2, \qquad\qquad h = y, f, \\ &\overline{h}_{it} = \tfrac{1}{10}\textstyle\sum_{j=0}^{9} h_{i,t-j}. \end{aligned}$$

ρ is calculated as follows

$$\rho_{it} = \frac{1}{9}\frac{\sum_{j=0}^{9}\left(y_{i,t-j} - \overline{y}_{it}\right)\left(f_{i,t-j} - \overline{f}_{it}\right)}{\sigma_{y_{i,t}}\sigma_{f_{i,t}}}.$$

8.2 Appendix of proofs

8.2.1 One-period model

The RC maximizes (4) by choosing c and g subject to (5). Combining the first order conditions, we obtain

$$h'(c) = h'(g), \tag{60}$$

or alternatively

$$c = g. \tag{61}$$

Taking into account (2), (3), (5), and (61) we obtain

$$c = g = \tfrac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right). \tag{62}$$

Considering the latter equality, $s_y = 1$ (private income shock) and $s_f = 1$ (fiscal transfer shock), then $\triangle g^f = \triangle g^y$. Similarly, $\triangle c^f = \triangle c^y$.

8.2.2 Two-period model with certainty

The RC maximizes (10) by choosing c_1, c_2, g_1 and g_2 subject to the constraint (11). The first order conditions are given by

$$h'(c_1) = h'(c_2) = h'(g_1) = h'(g_2), \tag{63}$$

or alternatively

$$c_1 = c_2 = g_1 = g_2. \tag{64}$$

Taking into account (8), (9), (11), (63) and (64) we obtain, analogously to (62),

$$c_1 = c_2 = g_1 = g_2 = \tfrac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right).$$

Considering the latter equality, $s_y = 1$ (income shock) and $s_f = 1$ (fiscal transfer shock), then $\triangle g_1^f = \triangle g_1^y$. Similarly, $\triangle c_1^f = \triangle c_1^y$.

8.2.3 Two period model with uncertainty and complete markets

The RC maximizes (20) by choosing c_1, $c_2(\varepsilon_y, \varepsilon_f)$, g_1, $g_2(\varepsilon_y, \varepsilon_f)$ subject to the constraint (37) and the fair insurance condition $q(\varepsilon_y, \varepsilon_f) = p(\varepsilon_y, \varepsilon_f)$. The first order conditions are given by

$$h'(c_1) = h'(c_2) = h'(g_1) = h'(g_2), \tag{65}$$

or alternatively

$$c_1 = c_2 = g_1 = g_2. \tag{66}$$

Taking into account (14)-(17), (37), (65), (66) and $q(\varepsilon_y, \varepsilon_f) = p(\varepsilon_y, \varepsilon_f)$, we obtain

$$c_1 = c_2 = g_1 = g_2 = \tfrac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right).$$

Considering the latter equality, $s_y = 1$ (income shock) and $s_f = 1$ (fiscal transfer shock), then $\triangle g_1^f = \triangle g_1^y$. Similarly, $\triangle c_1^f = \triangle c_1^y$.

8.2.4 Two-period model with uncertainty and incomplete markets

The RC chooses c_1, $c_2(\varepsilon_y, \varepsilon_f)$, g_1, and $g_2(\varepsilon_y, \varepsilon_f)$ to maximize (20) subject to the intertemporal constraint (41). From the first order conditions, we obtain

$$e^{-c_1} = e^{-g_1} = E\left[e^{-c_2}\right] = E\left[e^{-g_2}\right], \tag{67}$$

or alternatively

$$c_1/g_1 = c_2/g_2 = 1. \tag{68}$$

We can use (41), (67), (68) and (15)-(17) to express $g_2(\varepsilon_y, \varepsilon_f)$ as follows

$$g_2 = \frac{1}{2}(2+r)\left(\overline{y} + s_y + \overline{f} + s_f\right) + \frac{1}{2}\left(\varepsilon_y\left(\overline{y} + s_y\right) + \varepsilon_f\left(\overline{f} + s_f\right)\right) - g_1(1+r).$$

Since $\varepsilon_y \sim N\left(0, \sigma^2_{\varepsilon_y}\right)$, $\varepsilon_f \sim N\left(0, \sigma^2_{\varepsilon_f}\right)$ and ε_y and ε_f are jointly normally distributed it follows that

$$-g_2 \sim N\left(E\left[-g_2\right], \sigma^2_{-g_2}\right), \tag{69}$$
$$E\left[-g_2\right] = -\tfrac{1}{2}\left(2+r\right)\left(\overline{y} + s_y + \overline{f} + s_f\right) + \left(1+r\right) g_1, \tag{70}$$
$$\sigma^2_{-g_2} = \tfrac{1}{4}\sigma^2_{y_2+f_2}, \tag{71}$$

where ρ is the correlation between ε_y and ε_f and $\sigma^2_{y_2+f_2}$ is characterized by (25). Knowing that if a variable $x \sim N\left(E\left[x\right], \sigma^2_x\right)$ then $E\left[e^x\right] = e^{E[x]+\frac{\sigma^2_x}{2}}$, we can use (69)-(71) to obtain

$$E\left[e^{-g_2}\right] = e^{E[-g_2]+\frac{\sigma^2_{-g_2}}{2}}.$$

Using this last expression, we can rewrite the stochastic Euler equation (67) as

$$e^{-g_1} = e^{E[-g_2]+\frac{\sigma^2_{-g_2}}{2}},$$

which reduces to

$$E\left[g_2\right] = g_1 + \tfrac{1}{8}\sigma^2_{y_2+f_2}. \tag{72}$$

Since the intertemporal constraint holds for every state of nature, it holds in expected value. Hence:

$$c_1 + g_1 + \tfrac{E[c_2]+E[g_2]}{1+r} = y_1 + f_1 + \tfrac{E[y_2]+E[f_2]}{1+r}. \tag{73}$$

Precautionary savings (PS) are the additional savings that result from the fact that future incomes are uncertain and that asset markets are incomplete. In our two period model, PS is the difference in period 1 savings between the model with uncertainty and incomplete markets and the one under complete markets. Combining (14)-(17), (68), (72), and (73), we obtain

$$c_1 = g_1 = \tfrac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right) - \tfrac{1}{2}PS, \tag{74}$$
$$E\left[c_2\right] = E\left[g_2\right] = \tfrac{1}{2}\left(\overline{y} + s_y + \overline{f} + s_f\right) + \tfrac{1}{2}\left(1+r\right)PS, \tag{75}$$
$$PS = A\sigma^2_{y_2+f_2}, \tag{76}$$

where $A \equiv 1/(4\left(2+r\right)) > 0$ and $\sigma^2_{y_2+f_2}$ is characterized by (25).

Taking into account (i) equations (1), (18), (19), (25), (74)-(76), (ii) the fact that $s_y = s_f = 0$ before the shock, (iii) that an income shock consists in an increase in s_y such that $\triangle y_1 = \triangle E\left(y_2\right) = 1$ (i.e., $s_y = 1$) and (iv) that a fiscal transfer shock consists in an increase in s_f such that $\triangle f_1 = \triangle E(f_2) = 1$ (i.e., $s_f = 1$), it follows that

$$\triangle\left(\sigma^2_{y_2+f_2}\right)^y = (1+B)\,\sigma^2_{\varepsilon_y} + \alpha B \sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho, \tag{77}$$

$$\triangle\left(\sigma^2_{y_2+f_2}\right)^f = (1+\alpha B)\,\sigma^2_{\varepsilon_f} + B \sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho, \tag{78}$$

$$\triangle PS^y = A\triangle\left(\sigma^2_{y_2+f_2}\right)^y, \tag{79}$$

$$\triangle PS^f = A\triangle\left(\sigma^2_{y_2+f_2}\right)^f, \tag{80}$$

$$\triangle g_1^y = \tfrac{1}{2} - \tfrac{1}{2}\triangle PS^y, \tag{81}$$

$$\triangle g_1^f = \tfrac{1}{2} - \tfrac{1}{2}\triangle PS^f, \tag{82}$$

$$FP = \tfrac{1}{2}A\left[(1+B)\,\sigma^2_{\varepsilon_y} - (1+\alpha B)\,\sigma^2_{\varepsilon_f} - B(1-\alpha)\,\sigma_{\varepsilon_y}\sigma_{\varepsilon_f}\rho\right], \tag{83}$$

where $B \equiv 2\phi\overline{x} > 0$ and $\alpha \equiv (1-\phi)/\phi \in (0,1)$ assuming $1 > \phi > 0.5$. From (81) and (82), it is clear that the propensity of the government to spend out of output and federal transfers depends on the response of precautionary savings to those shocks.

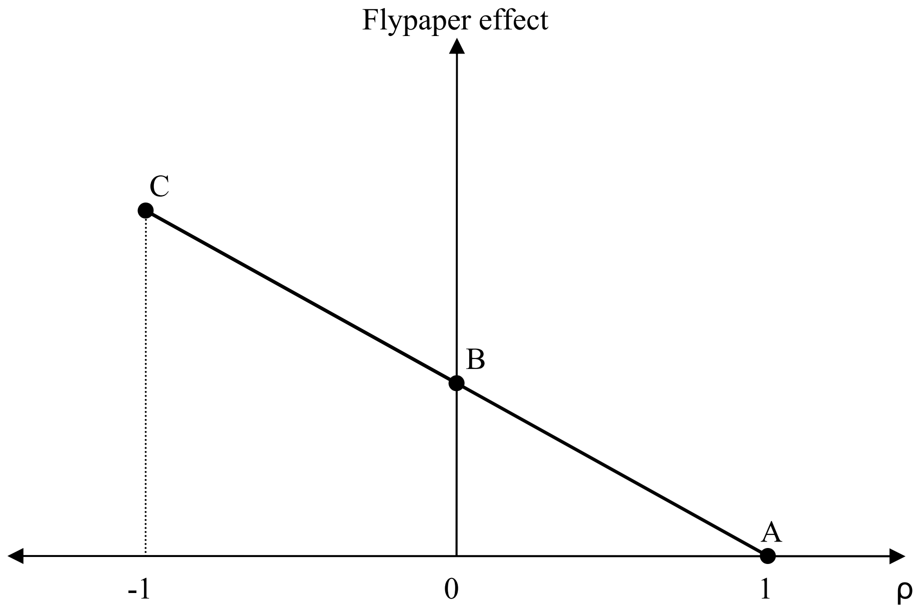
The following table shows all possible derivatives of (81) and (83) with respect to σ_y, σ_f, and ρ.

	$x = \triangle g_1^f$	$x = \triangle g_1^y$	$x = FP$[24]
$\frac{d(x)}{d\sigma_{\varepsilon_y}}$	$-GAB\sigma_{\varepsilon_f}\rho \gtreqless 0$	$-GAE \gtreqless 0$	$GAJ \gtreqless 0$
$\frac{d(x)}{d\sigma_{\varepsilon_f}}$	$-GAH \gtreqless 0$	$-GAB\alpha\sigma_{\varepsilon_y}\rho \gtreqless 0$	$-GAK \gtreqless 0$
$\frac{d(x)}{d\rho}$	$-GAB\sigma_{\varepsilon_y}\sigma_{\varepsilon_f} < 0$	$-GAB\alpha\sigma_{\varepsilon_y}\sigma_{\varepsilon_f} < 0$	$-GAB(1-\alpha)\,\sigma_{\varepsilon_y}\sigma_{\varepsilon_f} < 0$
$\frac{d^2(x)}{d\sigma_{\varepsilon_y}d\sigma_{\varepsilon_f}}$	$-GAB\rho \gtreqless 0$	$-GAB\alpha\rho \gtreqless 0$	$-GAB(1-\alpha)\,\rho \gtreqless 0$
$\frac{d^2(x)}{d\sigma_{\varepsilon_y}d\rho}$	$-GAB\sigma_{\varepsilon_f} < 0$	$-GAB\alpha\sigma_{\varepsilon_f} < 0$	$-GAB(1-\alpha)\,\sigma_{\varepsilon_f} < 0$
$\frac{d^2(x)}{d\sigma_{\varepsilon_f}d\rho}$	$-GAB\sigma_{\varepsilon_y} < 0$	$-GAB\alpha\sigma_{\varepsilon_y} < 0$	$-GAB(1-\alpha)\,\sigma_{\varepsilon_y} < 0$
$\frac{d^3(x)}{d\sigma_{\varepsilon_y}d\sigma_{\varepsilon_f}d\rho}$	$-GAB < 0$	$-GAB\alpha < 0$	$-GAB(1-\alpha) < 0$

where $B \equiv 2\phi\overline{x} > 0$, $E \equiv 2(1+B)\,\sigma_{\varepsilon_y} + \alpha B\sigma_{\varepsilon_f}\rho \gtreqless 0$, $G \equiv 1/2 > 0$, $H \equiv 2(1+\alpha B)\,\sigma_{\varepsilon_f} + B\sigma_{\varepsilon_y}\rho \gtreqless 0$, $J \equiv 2(1+B)\,\sigma_{\varepsilon_y} - B(1-\alpha)\,\sigma_{\varepsilon_f}\rho \gtreqless 0$ and $K \equiv 2(1+\alpha B)\,\sigma_{\varepsilon_f} + B(1-\alpha)\,\sigma_{\varepsilon_y}\rho \gtreqless 0$.

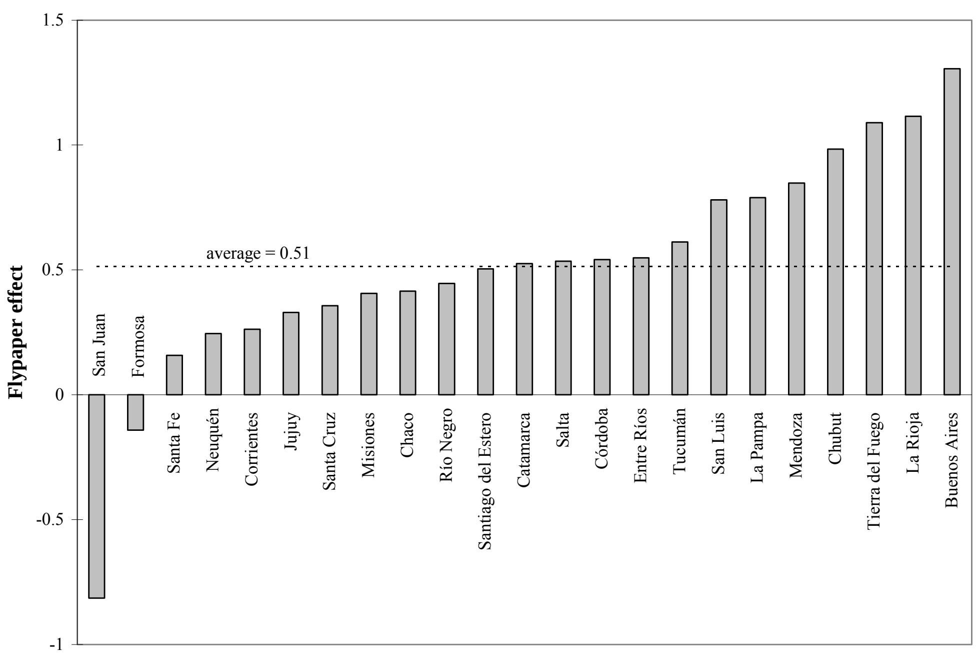
[24] We assume that $1 > \phi > 0.5$.

Figure 1. Flypaper effect as a function of the correlation between private income and fiscal transfers (ρ).



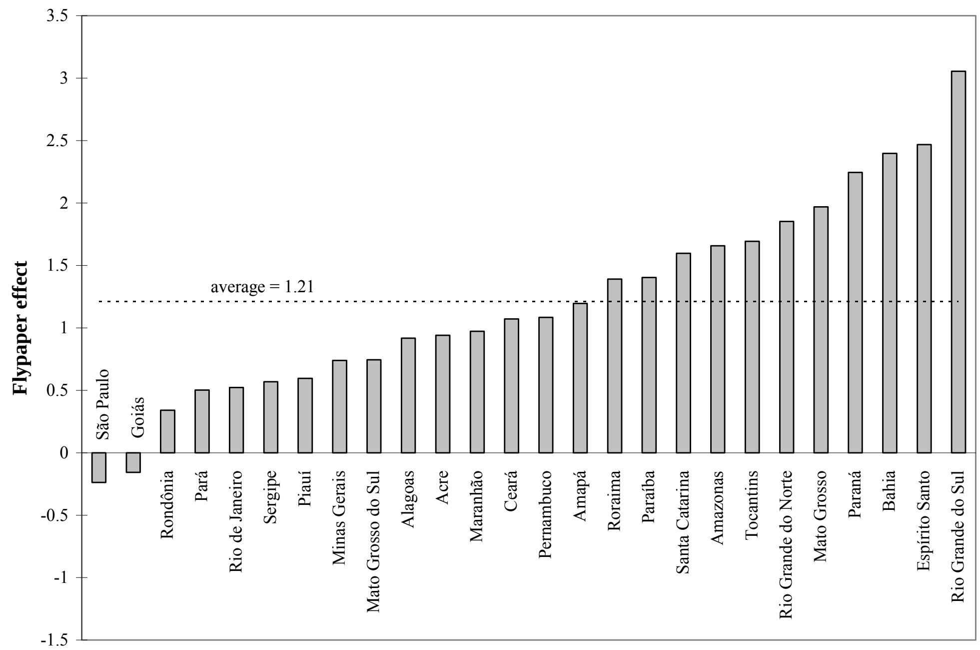
Note: This plot assumes that the variances of private income and fiscal transfers are equal and that the initial share of fiscal transfers in total income is smaller than the one of private income.

Figure 2. Flypaper effect across Argentinean provinces (1963-2006).



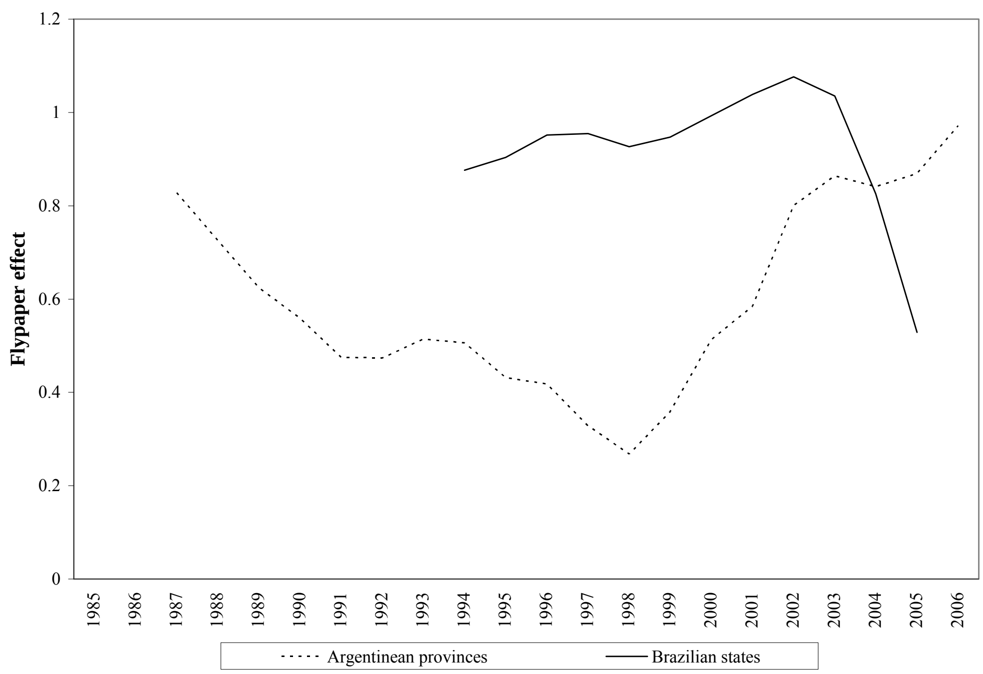
Note: Each individual regression includes pop. density and governor pre-elector period as control variables.

Figure 3. Flypaper effect across Brazilian states (1985-2005).



Note: Each individual regression also includes pop. density and governor pre-elector period as control variables.

Figure 4. Flypaper effect across Argentinean provinces (1963-2006)
and Brazilian states (1985-2005).



Note: Each panel fixed effect regression also includes pop. density and mayor pre-elector period as control variables. 25 year rolling window is used for Argentinean provinces. 10 year rolling window is used for Brazilian states.

Table 1. Basic macroeconomic and fiscal statistics. Argentinean provinces (1963-2006).

	GSP (as % of Argentinean GDP)	Fiscal transfers (as % of expenditures)	Correlation between cyclical components of GSP and fiscal transfers. 10 year rolling window. 25 percentile	median	75 percentile
	(1)	(2)	(3)	(4)	(5)
Buenos Aires	34.2	28.6	-0.09	0.37	0.71
Catamarca	0.5	48.5	0.08	0.20	0.53
Chaco	1.1	47.7	-0.08	0.69	0.83
Chubut	1.8	29.3	-0.33	-0.01	0.51
Córdoba	7.3	33.3	0.17	0.47	0.62
Corrientes	1.5	48.2	-0.48	0.11	0.47
Entre Ríos	2.5	40.8	-0.19	-0.05	0.23
Formosa	0.5	47.7	-0.01	0.36	0.72
Jujuy	0.9	41.6	-0.37	-0.12	0.10
La Pampa	0.9	38.6	0.07	0.46	0.75
La Rioja	0.5	38.9	0.12	0.37	0.74
Mendoza	3.4	32.7	-0.32	0.05	0.55
Misiones	1.2	47.5	-0.30	0.11	0.38
Neuquén	2.0	24.0	-0.37	-0.07	0.31
Río Negro	1.5	33.1	-0.18	0.02	0.26
Salta	1.6	41.8	0.09	0.50	0.80
San Juan	1.0	42.9	0.21	0.54	0.61
San Luis	1.1	46.2	0.12	0.41	0.60
Santa Cruz	0.9	25.0	-0.57	-0.39	0.02
Santa Fe	9.2	34.3	-0.26	0.15	0.55
Santiago del Estero	0.9	50.7	-0.16	0.24	0.46
Tierra del Fuego	0.4	19.1	-0.66	-0.29	0.05
Tucumán	2.6	41.7	-0.06	0.32	0.54
Average	3.4	38.4	-0.16	0.19	0.49
Min	0.4	19.1	-0.66	-0.39	0.02
Max	34.2	50.7	0.21	0.69	0.83

Notes: GSP stands for gross subnational product, in this case gross provincial product.

Table 2. Basic macroeconomic and fiscal statistics. Brazilian states (1985-2005).

	GSP (as % of Brazilian GDP)	Fiscal transfers (as % of expenditures)	Correlation between cyclical components of GSP and fiscal transfers. 10 year rolling 25 percentile	median	75 percentile
	(1)	(2)	(3)	(4)	(5)
Acre	2.4	77.5	-0.05	0.20	0.32
Alagoas	1.9	47.8	0.28	0.35	0.43
Amapá	3.4	89.7	0.54	0.60	0.68
Amazonas	5.2	27.1	0.16	0.29	0.37
Bahia	2.7	26.6	-0.09	-0.07	0.02
Ceará	2.0	32.9	-0.60	-0.46	-0.44
Espírito Santo	4.8	18.2	-0.38	-0.28	-0.06
Goiás	3.2	17.5	0.37	0.40	0.61
Maranhão	1.3	62.0	-0.43	-0.36	-0.09
Mato Grosso	3.8	22.5	-0.59	-0.47	-0.43
Mato Grosso do Sul	4.0	19.4	0.06	0.18	0.21
Minas Gerais	4.2	15.9	-0.53	-0.12	0.16
Paraná	5.0	16.1	-0.04	0.15	0.31
Paraíba	1.8	46.0	-0.29	-0.10	-0.05
Pará	2.5	46.0	-0.43	-0.24	-0.17
Pernambuco	2.6	31.2	-0.64	-0.46	-0.13
Piauí	1.3	57.6	0.32	0.46	0.58
Rio Grande do Norte	2.2	45.8	-0.19	-0.09	0.10
Rio Grande do Sul	6.1	12.0	-0.55	-0.48	-0.13
Rio de Janeiro	6.4	11.8	-0.58	-0.52	-0.27
Rondônia	3.1	49.6	0.04	0.59	0.65
Roraima	2.8	81.5	0.68	0.74	0.86
Santa Catarina	5.6	14.8	-0.06	0.04	0.35
Sergipe	2.9	47.7	0.15	0.19	0.33
São Paulo	7.7	7.4	-0.52	-0.15	0.65
Tocantins	1.8	62.6	0.01	0.06	0.17
Average	3.5	38.0	-0.13	0.02	0.19
Min	1.3	7.4	-0.64	-0.52	-0.44
Max	7.7	89.7	0.68	0.74	0.86

Notes: GSP stands for gross subnational product, in this case gross state product.

Table 3. Evolution of secondary distribution shares for provincial governments according to different Argentinean laws. 1963-2006

	1963-1972	1973-1980	1981-1984	1988-1991	1992-2006
Buenos Aires	29.7	28	28.3	21.9	24.8
Catamarca	2.1	1.9	1.9	2.7	2.6
Chaco	3.4	4.1	4	5	4.3
Chubut	1.9	1.9	1.9	1.6	1.9
Cordoba	8.6	8.9	9	8.8	8.1
Corrientes	3.5	3.8	3.6	3.7	3.5
Entre Rios	4.4	4.6	4.1	4.9	4.6
Formosa	1.8	2.3	2.3	3.6	3.3
Jujuy	2.3	2.2	2.2	2.8	2.8
La Pampa	2	1.8	1.7	1.9	1.9
La Rioja	1.7	1.7	1.7	2.1	2
Mendoza	5.5	4.7	4.8	4.1	4.1
Misiones	2.7	3	2.9	3.3	3.3
Neuquén	1.7	1.7	1.9	1.7	2
Rio Negro	2.2	2.3	2.5	2.5	2.5
Salta	3	3.5	3.8	3.8	3.7
San Juan	2.9	2.6	2.5	3.4	3.2
San Luis	1.8	1.7	1.7	2.3	2.2
Santa Cruz	1.8	1.4	1.6	1.6	1.7
Santa Fe	9.6	9.1	8.6	8.8	8.1
Santiago del Estero	2.8	4	4	4.1	3.8
Tierra del Fuego	0.3	0.3	0.3	0.7	1.1
Tucuman	4.3	4.4	4.7	4.7	4.5
Total	100	100	100	100	100

Source: Porto (2004) and several Argentinean laws.

Table 4. Flypaper effect. Benchmark results. Argentinean provinces (1963-2006).

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
y	(coef. β_y)	0.1***	0.1***	0.1***	0.09***	0.09***	0.09***	0.09***	0.06***
		[40.36]	[18.93]	[8.83]	[5.58]	[5.51]	[5.44]	[6.95]	[5.15]
f	(coef. β_f)	1.96***	1.96***	1.96***	1.89***	1.85***	1.80***	1.36***	0.76**
		[33.87]	[26.36]	[10.36]	[9.55]	[9.14]	[8.97]	[6.77]	[2.20]
terrain roughness					46.07**	46.24**	47.13**		
					[2.20]	[2.31]	[2.34]		
water bodies					14.84*	15.03*	15.65*		
					[1.98]	[1.99]	[2.07]		
pop. density						-1.07*	-1.30**	5.42**	-6.24**
						[-1.73]	[-2.24]	[2.19]	[-2.18]
governor pre-electoral period							89.23***	100.18***	-104.83
							[3.35]	[3.16]	[-0.70]
Flypaper effect observed:									
FP = β_f - β_y		1.86***	1.86***	1.86***	1.81***	1.77***	1.71***	1.28***	0.69*
		(1012)	(614.8)	(103.2)	(92.51)	(84.10)	(81.00)	(42.14)	(4.26)
Statistics:									
Province fixed effect		No	No	No	No	No	No	Yes	Yes
Year fixed effect		No	No	No	No	No	No	No	Yes
Standard errors		standard	robust	robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster
Observations		1012	1012	1012	1012	1012	1012	1012	1012
Provinces		23	23	23	23	23	23	23	23
R^2		0.78	0.78	0.78	0.8	0.8	0.8	0.57	0.7

Notes: The dependent variable is the provincial government spending per capita (g). y and f stand for income and fiscal transfers per capita, respectively. R^2 for province fixed effect regressions (columns 7 and 8) corresponds to within R^2. Constant term is not reported. T-statistics are in square brackets. F-statistics are in parentheses. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

Table 5. Flypaper effect. Benchmark results. Brazilian states (1985-2005).

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
y	(coef. β_y)	0.09***	0.09***	0.09***	0.11***	0.11***	0.11***	0.01	0.01
		[27.79]	[24.33]	[14.46]	[11.91]	[12.66]	[12.67]	[0.09]	[0.64]
f	(coef. β_f)	0.89***	0.89***	0.89***	0.87***	0.88***	0.87***	1.02***	1.00***
		[48.16]	[31.03]	[17.81]	[20.98]	[21.60]	[21.42]	[32.95]	[31.61]
terrain roughness					-13.93	-25.71	-24.46		
					[-0.65]	[-0.91]	[-0.87]		
water bodies					-70.92**	-77.89***	-77.01***		
					[-2.63]	[-2.86]	[-2.82]		
pop. density						0.10	0.09	1.82***	1.89***
						[0.85]	[0.78]	[3.30]	[3.02]
governor pre-electoral period							49.70***	37.62**	16.35
							[2.79]	[2.15]	[0.27]
Flypaper effect observed:									
FP = β_f - β_y		0.8***	0.8***	0.8***	0.76***	0.77***	0.76***	1.01***	0.99***
		(1921)	(790.6)	(254.9)	(274.3)	(290.2)	(286.1)	(469.2)	(509.9)
Statistics:									
State fixed effect		No	No	No	No	No	No	Yes	Yes
Year fixed effect		No	No	No	No	No	No	No	Yes
Standard errors		standard	robust	robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster
Observations		541	541	541	541	541	541	541	541
States		26	26	26	26	26	26	26	26
R^2		0.83	0.83	0.83	0.84	0.84	0.85	0.6	0.63

Notes: The dependent variable is the state government spending per capita (g). y and f stand for income and fiscal transfers per capita, respectively. R^2 for province fixed effect regressions (columns 7 and 8) corresponds to within R^2. Constant term is not reported. T-statistics in square brackets. F-statistics are in parentheses. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

Table 6. Flypaper effect. Insurance arguments. Argentinean provinces (1963-2006) and Brazilian states (1985-2005).

		Argentinean provinces (1)	Brazilian states (2)	expected sign
y	(coef. β_y)	0.06***	0.06*	
		[3.56]	[1.97]	
f	(coef. β_f)	0.71***	1.22***	
		[3.31]	[5.32]	
$\rho \bullet y$	(coef. α_2)	0.01	-0.01	-
		[0.55]	[-0.13]	
$\rho \bullet f$	(coef. α_3)	-0.78***	-0.48***	-
		[-3.4]	[-3.07]	
$\sigma_y^2 \bullet y$	(coef. α_5)	-0.1	0.41	+/-
		[-0.68]	[0.99]	
$\sigma_y^2 \bullet f$	(coef. α_6)	-15.55**	-2.54	+/-
		[-2.73]	[-0.92]	
$\sigma_f^2 \bullet y$	(coef. α_8)	-0.06***	0.06	+/-
		[-3.25]	[1.01]	
$\sigma_f^2 \bullet f$	(coef. α_9)	-3.06***	-1.85***	+/-
		[-3.25]	[-3.38]	
$\sigma_y^2 \bullet \rho \bullet y$	(coef. α_{11})	0.22	-2.28**	-
		[0.95]	[-2.22]	
$\sigma_y^2 \bullet \rho \bullet f$	(coef. α_{12})	22.20**	7.13	-
		[2.81]	[1.58]	
$\sigma_f^2 \bullet \rho \bullet y$	(coef. α_{14})	0.02	0.3	-
		[0.33]	[1.67]	
$\sigma_f^2 \bullet \rho \bullet f$	(coef. α_{15})	5.30***	3.98***	-
		[3.52]	[3.07]	
$\sigma_y^2 \bullet \sigma_f^2 \bullet y$	(coef. α_{17})	0.1	-3.47	+/-
		[0.17]	[-1.3]	
$\sigma_y^2 \bullet \sigma_f^2 \bullet f$	(coef. α_{18})	76.42***	41.08***	+/-
		[4.99]	[3.47]	
$\sigma_y^2 \bullet \sigma_f^2 \bullet \rho \bullet y$	(coef. α_{20})	-1.62**	4.42	-
		[-2.08]	[1.02]	
$\sigma_y^2 \bullet \sigma_f^2 \bullet \rho \bullet f$	(coef. α_{21})	-106.63***	-65.19***	-
		[-4.3]	[-4.74]	
Size of flypaper effect (FP) evaluated at different values of σ_y^2, σ_f^2 and ρ:				
FP(max σ_y^2, max σ_f^2, max ρ)		-4.32	-1.39	
		(-1.40)	(1.18)	
FP(max σ_y^2, max σ_f^2, min ρ)		36.8***	21.03***	
		(29.48)	(11.12)	
FP(min σ_y^2, min σ_f^2, min ρ)		1.28***	1.28***	
		(25.35)	(22.56)	
Statistics:				
Subnational fixed effect		Yes	Yes	
Year fixed effect		Yes	Yes	
Standard errors		robust and cluster	robust and cluster	
Controls		Yes	Yes	
Observations		805	307	
Subnational units		23	26	
R^2		0.71	0.53	

Notes: The dependent variable is the provincial government spending per capita (g). y and f stand for income and fiscal transfers per capita, respectively. R^2 in all regressions corresponds to within R^2. Constant and interaction terms ρ, σ_y^2, σ_f^2, $\sigma_f^2 \bullet \sigma_y^2$, $\sigma_y^2 \bullet \rho$, $\sigma_f^2 \bullet \rho$ and $\sigma_f^2 \bullet \sigma_y^2 \bullet \rho$ are not reported. Pop. density and governor pre-electoral period coefficients are not reported either; Controls reflect whether these two variables were included in the regression. Coefficients name (e.g., coef. α_3) refer to equation (59), page 18. The last column "expected sign" characterized the signs of the derivatives obtained in the theoretical model. T-statistics are in square brackets. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

Argentinean provinces: Max σ_y^2=0.3141, max σ_f^2=1, max ρ=0.9815, min σ_y^2=0.0005, min σ_f^2=0.01, min ρ= -0.9322.

Brazilian states: Max σ_y^2=0.2644, max σ_f^2=1, max ρ=0.8808, min σ_y^2=0.002, min σ_f^2=0.013, min ρ= -0.8256.

Table 7. Flypaper effect. Insurance arguments. Argentinean provinces (1963-2006) and Brazilian states (1985-2005).

		Argentinean provinces (1)	Argentinean provinces (2)	Argentinean provinces (3)	Brazilian states (4)	Brazilian states (5)	Brazilian states (6)	expected sign
y	(coef. β_y)	0.05***	0.03*	0.05***	0.03	0.03	0.04**	
		[3.32]	[1.99]	[3.36]	[0.7]	[1.19]	[2.07]	
f	(coef. β_f)	0.2	0.14	0.14	1.1***	1.17***	1.32***	
		[0.83]	[1.01]	[0.64]	[5.24]	[6.34]	[5.76]	
$\rho \bullet y$	(coef. α_2)	-0.01	0.03***	0.04***	0.03	0.07***	-0.02	-
		[-0.1]	[3.32]	[5.28]	[0.94]	[4.39]	[-1.13]	
$\rho \bullet f$	(coef. α_3)	-0.23	0.26*	0.06	-0.16	-0.1	-0.46**	-
		[-0.84]	[2.06]	[0.34]	[-0.95]	[-0.75]	[-2.74]	
$\sigma_y^2 \bullet y$	(coef. α_5)		0.02			0.09		+/-
			[0.16]			[0.32]		
$\sigma_y^2 \bullet f$	(coef. α_6)		7.75***			0.26		+/-
			[4.96]			[0.12]		
$\sigma_f^2 \bullet y$	(coef. α_8)			-0.07***			0.06	+/-
				[-4.3]			[1.53]	
$\sigma_f^2 \bullet f$	(coef. α_9)			0.71			-0.86	+/-
				[1.58]			[-0.97]	
$\sigma_y^2 \bullet \rho \bullet y$	(coef. α_{11})		-0.3***			-1.5***		-
			[-4.68]			[-4.68]		
$\sigma_y^2 \bullet \rho \bullet f$	(coef. α_{12})		-9.8***			0.17		-
			[-5.51]			[0.04]		
$\sigma_f^2 \bullet \rho \bullet y$	(coef. α_{14})			-0.15***			0.19	-
				[-7.55]			[1.58]	
$\sigma_f^2 \bullet \rho \bullet f$	(coef. α_{15})			-1.62			2.46*	-
				[-1.62]			[1.89]	
Statistics:								
Subnational fixed effect		Yes	Yes	Yes	Yes	Yes	Yes	
Year fixed effect		Yes	Yes	Yes	Yes	Yes	Yes	
Standard errors		robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster	robust and cluster	
Controls		Yes	Yes	Yes	Yes	Yes	Yes	
Observations		805	805	805	307	307	307	
Subnational units		23	23	23	26	26	26	
R^2		0.56	0.63	0.61	0.4	0.47	0.49	

Notes: The dependent variable is the provincial government spending per capita (g). y and f stand for income and fiscal transfers per capita, respectively. R^2 in all regressions corresponds to within R^2. Constant and interaction terms ρ, σ_y^2, σ_f^2, $\sigma_y^2 \bullet \rho$ and $\sigma_f^2 \bullet \rho$ are not reported. Pop. density and governor pre-electoral period coefficients are not reported either; Controls reflect whether these two variables were included in the regression. Coefficients name (e.g., coef. α_3) refer to equation (59), page 18. The last column "expected sign" characterized the signs of the derivatives obtained in the theoretical model. T-statistics are in square brackets. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.