XX

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COUPLED VS. DECOUPLED SUBSIDIES WITH HETEROGENEOUS FIRMS IN GENERAL EQUILIBRIUM

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We develop a competitive general equilibrium model with heterogeneous firms and endogenous entry and exit to contrast the effects of coupled and decoupled subsidies. Unlike coupled subsidies, decoupled subsidies are not tied to a producer's level of output, so they are thought to be less distortive. We challenge this view by proving that, in a model with endogenous TFP, coupled subsidies have no effect on TFP while decoupled subsidies have a negative effect. Moreover, our numerical experiments show that, for a given level of government expenditure, decoupled subsidies can lower welfare more than coupled subsidies.

JEL classification codes: O4, L0, L2, L5
Key words: policy distortions, firm heterogeneity, productivity

I. Introduction

The allocation of resources across firms is a key factor in understanding total factor productivity (TFP). Given the importance of TFP in accounting for macroeconomic fluctuations, it is crucial to understand how government policies affect this residual (see, for example, Kehoe and Prescott 2007). Government subsidies to producers may lower TFP by propping up low-productivity establishments that would otherwise exit. The objective of this study is to contrast the effects of two broad types of

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government subsidies to firms. *Coupled subsidies* are tied to the level of output, such as price supports. *Decoupled subsidies* are independent of the level of output, such as direct payments to producers. We are particularly concerned with how these subsidies affect firm entry and exit, aggregate TFP, and social welfare. It is commonly thought that decoupled subsidies are less distortive. For example, in a model with a representative firm, decoupled subsidies that are financed by lump-sum taxes are entirely non-distortionary. We instead consider a model in which heterogeneous firms make endogenous entry and exit decisions. In this setting, we prove that decoupled subsidies negatively affect TFP, while coupled subsidies do not. We also show that, contrary to conventional wisdom, decoupled subsidies can cause larger welfare losses than coupled subsidies for a given level of government expenditure.

To contrast the effects of these subsidies, we take a static one-sector model and incorporate the competitive industrial organization theory of Hopenhayn (1992), but in a general equilibrium setting, as in Hopenhayn and Rogerson (1993) (though their application is employment distortions). In the model, firms make endogenous entry, operating, and exit decisions. After paying a fixed cost of entry, a firm draws its productivity from a continuous probability distribution. Each firm can operate a technology with decreasing returns to scale, but there is a fixed cost of operating, so low-productivity firms may choose to exit rather than operate. This creates an endogenous productivity cutoff for operating, which in turn makes aggregate TFP endogenous in the model. The model also has a representative consumer that makes a labor–leisure decision and a government that offers subsidies to firms and finances them through a lump-sum tax on the consumer. (We do not incorporate distortionary taxes so as to isolate the distortionary effects of the subsidies.) We model the coupled subsidy as a flat-rate output subsidy and the decoupled subsidy as a lump-sum operating subsidy.

We conduct both qualitative and quantitative analysis of the policies. A crucial difference between the two subsidies is in their effect on TFP. We prove that the lump-sum operating subsidy lowers TFP, while the output subsidy has no effect on TFP. In general equilibrium, the output subsidy raises the wage so as to leave firms' profits, and therefore the productivity cutoff for operating, unchanged. Other effects of the two types of subsidies are qualitatively the same, so we turn to quantitative policy experiments. In order to directly compare the policies, we consider coupled and decoupled policy pairs such that the level of government expenditure on each subsidy is the same. Using standard functional forms and parameter values, we show that decoupled subsidies lead to larger welfare losses than coupled subsidies.

The policy debate over coupled vs. decoupled subsidies is particularly prominent in the agricultural sector, which is a heavily subsidized sector in many countries.

In some countries, there was a shift from coupled subsidies to decoupled subsidies, as policy makers thought decoupled subsidies were less distortive. Bhaskar and Beghin (2009) provide an overview of the debate and identify a number of channels through which decoupled subsidies may have distortionary effects. The channels considered do not, however, include general-equilibrium effects in a model with heterogeneous firms and endogenous entry and exit.

This paper contributes to the literature on the link between government policy distortions and cross-country differences in productivity. Our interest is in directly comparing the effects of coupled and decoupled subsidies in a setting where the subsidies are common to all firms. A number of papers instead consider idiosyncratic policy distortions in models with heterogeneous firms (typically low-productivity producers are favored to the detriment of high-productivity producers). Guner et al. (2008) analyze a model in which the government promotes small firms at the expense of large firms. Restuccia and Rogerson (2008) consider idiosyncratic taxes on firms, which leads to different after-tax prices for goods and a misallocation of resources across establishments. If the taxes are correlated with firm size, the aggregate distortions are large. Fattal (2012) emphasizes the role of endogenous entry and exit of firms. Allowing for endogenous entry and exit substantially decreases the welfare gains from removing distortionary policies. Da Rocha and Pujolas (2011) analyze the effects of idiosyncratic shocks and use Brownian motion to obtain an endogenous distribution of plants. Their model shows that failure to account for firm-level idiosyncratic shocks and endogenous exit results in overestimation of the TFP gain when policy distortions are removed. Buera et al. (2013) develop a model in which heterogeneous individuals each choose whether to be an entrepreneur or a worker. Entrepreneurs are initially subsidized, which leads to positive short-run effects when they have high productivity. As entrepreneurs lose their competitive edge, however, they remain propped up by subsidized capital. This causes substantial long-run drops in output and productivity.

The next section presents the model and defines an equilibrium. Section III provides qualitative analysis of the model, deriving an aggregate production function and performing comparative statics. Section IV presents quantitative analysis of the model. Section V concludes the paper.

II. Model

We develop a static competitive general equilibrium model with a continuum of heterogeneous single-plant firms that make endogenous operating and exit decisions.

The firms produce a homogeneous good that serves as the numeraire. The model also has a representative consumer that makes a labor–leisure decision and a government that offers subsidies to firms and finances them with lump-sum taxes.

A. Consumer

There is a representative consumer who is endowed with one unit of time available for market work. The consumer derives utility from consumption and leisure according to a standard utility function

$$u(C, 1 - L_s), \tag{1}$$

where C is consumption, L_s is labor supply, and $1 - L_s$ is leisure. The consumer allocates all after-tax income to consumption, so the budget constraint is

$$C = wL_s - T, \tag{2}$$

where w is the wage and T is a lump-sum tax.

B. Firms

There is a continuum of heterogeneous firms that differ in productivity. The firms competitively produce a homogeneous good. A firm with productivity draw z has the technology

$$y(z) = z^{1-v} l(z)^{v}, \tag{3}$$

where $y(z)$ is output and $l(z)$ is labor. Here $v \in (0,1)$ so that individual firms face decreasing returns to scale. The government gives each firm a lump-sum operating subsidy of σ_o and an output subsidy of σ_y. The fixed cost of operating is f_o units of output. The profits of a firm with productivity z are given by

$$\pi(z) = (1 + \sigma_y) y(z) - wl(z) - f_o + \sigma_o. \tag{4}$$

Profit maximization implies that labor demand from an operating firm with productivity z is

$$l(z) = z\left(\frac{v(1+\sigma_y)}{w}\right)^{\frac{1}{1-v}}. \tag{5}$$

Because of the fixed cost of operating, some firms may choose to exit rather than operate because they cannot earn positive profits. The cutoff for operating, $\bar{z}$, satisfies

$$\pi(\bar{z}) = 0. \tag{6}$$

The cost of entry is f_e units of output. A firm that pays the cost of entry receives a productivity draw from probability distribution $G(z)$ and then decides whether to operate or exit. Firms enter until the expected profits equal the cost. The free-entry condition is

$$\int_{\bar{z}}^{\infty} \pi(z)\,dG(z) = f_e. \tag{7}$$

C. Aggregation

Before specifying the rest of the equilibrium conditions, it is convenient to define a couple of aggregates. Let M_e denote the measure of entrants. We define total output, Y, and the measure of operating firms, M_o by aggregating over operating firms:

$$Y = M_e \int_{\bar{z}}^{\infty} y(z)\,dG(z), \tag{8}$$

$$M_o = M_e \int_{\bar{z}}^{\infty} dG(z). \tag{9}$$

D. Government

The government collects lump-sum taxes from the consumer and offers operating and output subsidies to producers. The government's budget constraint is

$$\sigma_o M_o + \sigma_y Y = T. \tag{10}$$

E. Market clearing

Output can be used for consumption and for payment of fixed costs. Clearing in the goods market requires that

$$C + f_o M_o + f_e M_e = Y. \tag{11}$$

Finally, clearing in the labor market requires that

$$M_e \int_{\bar{z}}^{\infty} l(z) dG(z) = L_s. \tag{12}$$

F. Equilibrium

Here we define an equilibrium and discuss how to calculate the equilibrium.

A *competitive equilibrium* consists of aggregates $\hat{Y}$, $\hat{L}_s$, $\hat{C}$, $\hat{M}_e$, $\hat{M}_o$, and $\hat{T}$; wage $\hat{w}$; and firm decision rules $\hat{l}(z)$, $\hat{y}(z)$, $\hat{\pi}(z)$, and $\bar{z}$ such that:

1. Given $\hat{w}$ and $\hat{T}$, the representative consumer chooses $\hat{C}$ and $\hat{L}_s$ to maximize utility (1) subject to the budget constraint (2).
2. Given $\hat{w}$, a firm with productivity z chooses $\hat{l}(z)$ and $\hat{y}(z)$ to maximize profits (4) subject to the technology constraint (3). Profits $\hat{\pi}(z)$ satisfy (4).
3. The cutoff for operating, $\bar{z}$, satisfies (6).
4. The aggregation conditions (8)–(9) hold.
5. The government's budget constraint (10) holds.
6. The market-clearing conditions for goods (11) and labor (12) hold.

Calculating the equilibrium can be reduced to finding the values of w and $\bar{z}$ that satisfy the zero-cutoff-profit condition (6) and the free-entry condition (7). After solving for the profit function, we have a system of two equations in two unknowns:

$$w^{\frac{-v}{1-v}} \bar{z}\left(1+\sigma_y\right)\left(v^{\frac{v}{1-v}} - v^{\frac{1}{1-v}}\right) - f_o + \sigma_o = 0 \tag{13}$$

$$\int_{\bar{z}}^{\infty}\left(w^{\frac{-v}{1-v}} z\left(1+\sigma_y\right)\left(v^{\frac{v}{1-v}} - v^{\frac{1}{1-v}}\right) - f_o + \sigma_o\right) dG(z) = f_e. \tag{14}$$

After solving this system, the measure of entrants, M_e, can be found using either one of the two market-clearing conditions (the other must hold by Walras's law). The rest of the equilibrium objects are then straightforward to calculate.

III. Qualitative analysis

Here we show how to derive the aggregate production function and an endogenous measure of TFP. Then we perform comparative statics to constrast each subsidy's effect on TFP.

Even though individual firms face decreasing returns to scale, there are constant returns to scale in the aggregate once the measure of operating firms, M_o, is taken into account. The following proposition shows this and defines our measure of TFP.

Proposition 1. *The aggregate production function* is

$$Y = ZL_s^{v} M_o^{1-v}, \tag{15}$$

where

$$Z = \left(\frac{1}{1-G(\bar{z})} \int_{\bar{z}}^{\infty} z dG(z) \right)^{1-v}. \tag{16}$$

Proof. First notice that, using (5), we can express the labor-market-clearing condition (12) as

$$M_e \left(\frac{v(1+\sigma_y)}{w} \right)^{\frac{1}{1-v}} \int_{\bar{z}}^{\infty} z dG(z) = L_s. \tag{17}$$

Using (8), (3), and (5), we have

$$Y = M_e \int_{\bar{z}}^{\infty} y(z) dG(z) \tag{18}$$

$$= M_e \int_{\bar{z}}^{\infty} z^{1-v} l(z)^{v} dG(z) \tag{19}$$

$$= M_e \left(\frac{v(1+\sigma_y)}{w} \right)^{\frac{v}{1-v}} \int_{\bar{z}}^{\infty} z dG(z). \tag{20}$$

Next we substitute in (17) to obtain

$$Y = \left(\int_{\bar{z}}^{\infty} z dG(z) \right)^{1-v} L_s^v M_e^{1-v} \tag{21}$$

Finally, by substituting in (9) and (16), we obtain (15).

Notice that TFP, Z, depends on a weighted average of operating firms' productivities, which in turn depends on the operating cutoff, $\bar{z}$. Since TFP depends on the operating cutoff, we next perform comparative statics to contrast how the subsidies affect the operating cutoff.

Proposition 2. *The cutoff for operating, $\bar{z}$, does not depend on the level of the output subsidy, σ_y, and is decreasing in the level of the operating subsidy, σ_o.*

Proof. First consider a change in the output subsidy of $d\sigma_y$. Totally differentiating (13) and (14), we obtain

$$-\frac{v}{1-v}\frac{dw}{w} + \frac{d\bar{z}}{\bar{z}} + \frac{d\sigma_y}{1+\sigma_y} = 0, \tag{22}$$

$$-\frac{v}{1-v}\frac{dw}{w} + \frac{d\sigma_y}{1+\sigma_y} = 0. \tag{23}$$

These equations imply that $\frac{d\bar{z}}{d\sigma_y} = 0$. Now consider a change in the operating subsidy of $d\sigma_o$. Using the same approach, we have

$$-\frac{v}{1-v}\frac{dw}{w} + \frac{d\bar{z}}{\bar{z}} + \frac{1}{\bar{z}} \frac{w^{\frac{v}{1-v}} d\sigma_o}{(1+\sigma_y)\left(v^{\frac{v}{1-v}} - v^{\frac{1}{1-v}} \right)} = 0, \tag{24}$$

$$-\frac{v}{1-v}\frac{dw}{w} + \frac{1-G(\bar{z})}{\int_{\bar{z}}^{\infty} z dG(z)} \frac{w^{\frac{v}{1-v}} d\sigma_o}{(1+\sigma_y)\left(v^{\frac{v}{1-v}} - v^{\frac{1}{1-v}} \right)} = 0. \tag{25}$$

We combine these equations to obtain

$$\frac{d\bar{z}}{d\sigma_o} = \left(\frac{1-G(\bar{z})}{\int_{\bar{z}}^{\infty} z dG(z)} - \frac{1}{\bar{z}} \right) \frac{w^{\frac{v}{1-v}} \bar{z}}{(1+\sigma_y)\left(v^{\frac{v}{1-v}} - v^{\frac{1}{1-v}} \right)} < 0. \tag{26}$$

The inequality follows from the first term in parentheses being negative.

The output subsidy does not affect TFP. Rather, the wage adjusts proportionally such that the operating cutoff remains unchanged. By contrast, the operating subsidy lowers the cutoff for operating and thereby decreases aggregate TFP.

Table 1. Parameterization of the model

Parameter	Value	Description
γ	0.3	Consumption weight
ν	0.85	Firm-level returns to scale
η	2.1	Pareto shape parameter
f_e	0.038	Fixed entry cost
f_o	0.083	Fixed operating cost

IV. Quantitative analysis

Here we parameterize the model and quantitatively contrast the effects of the subsidies. In our policy experiments, we compare the two types of subsidies assuming equal levels of government expenditure.

A. Parameterization

Rather than calibrating the model to a specific country and time, we make our numerical analysis as widely applicable as possible by using standard functional forms and parameter values. We parameterize the model assuming no policy distortions.

We specify the utility function (1) as Cobb-Douglas:

$$u(C,1-L_s)=C^{\gamma}(1-L_s)^{1-\gamma}, \tag{27}$$

where $\gamma \in (0,1)$. We set $\gamma = 0.3$ so that 30 percent of time is devoted to market work. Following Chaney (2008), we specify the distribution of productivity draws as a Pareto distribution with a lower bound of one:

$$G(z)= 1-z^{-\eta}. \tag{28}$$

The Pareto distribution is widely used in the heterogeneous firms literature because many studies find that the tail of the size distribution of firms is approximately

Pareto. Obtaining a finite variance requires that $\eta > 2$ and a number of studies using establishment-level data find that a value around two is consistent with the data, so we set $\eta = 2.1$. Following Restuccia and Rogerson (2008), we set $\nu = 0.85$. We choose the fixed costs, f_e and f_o, such that, in the benchmark with no distortions, the wage is equal to one and half of entrants choose to operate. Table 1 summarizes the parameterization.

B. Policy experiments

Here we use the parameterized model to conduct illustrative numerical experiments. To make our comparisons of the two subsidy types comparable, we choose the subsidy levels so that government expenditure on each type is the same. We consider output subsidies of 2, 4, and 6 percent. The levels of operating subsidies that require the same amount of government expenditure are 0.017, 0.027, and 0.035, respectively. (If the operating subsidies were much larger, the operating cutoff would no longer bind and all entrants would choose to operate.) We consider the effects of these policies along many dimensions relative to the benchmark of no policy distortions. In terms of welfare, since the utility function (27) is homogeneous of degree one, it is a perfect index of real income and serves as our measure of welfare. We also break down changes in output (15) using the following logarithmic decomposition:

$$d\log Y = d\log Z + \nu d\log L_s + (1 - \nu) d\log M_o. \tag{29}$$

Table 2 shows the effects of coupled subsidies, while Table 3 shows the effects of decoupled subsidies.

As the tables show, the effects of the two types of subsidies are qualitatively the same–except with respect to TFP–but differ quantitatively. For a given level of government expenditure, decoupled subsidies have larger effects than coupled subsidies with respect to output, labor supply, the measure of operating firms, and welfare, but have smaller effects with respect to wages, firm entry, and consumption. With both subsidies, the increase in consumption has a positive effect on welfare, but this is outweighed by the loss of leisure. The decomposition of output shows that, with respect to decoupled subsidies, even though there are substantial drops in TFP, output rises strongly due to increases in labor supply and especially increases in the measure of operating firms. With coupled subsidies, the rise in output is driven mostly by increases in labor supply.

Table 2. Effects of coupled subsidies, percentage change

Statistic	Policy		
	σ_y = 2%	σ_y = 4%	σ_y = 6%
$d \log Y$	1.977	3.911	5.802
$d \log Z$	0	0	0
$vd \log L_s$	1.384	2.736	4.058
$(1-v)\, d \log M_o$	0.594	1.175	1.744
w	2.357	4.722	7.100
M_e	4.037	8.148	12.332
Welfare	-0.007	-0.028	-0.061
C	1.637	3.254	4.851
$1-L_s$	-0.703	-1.402	-2.095

Table 3. Effects of decoupled subsidies, percentage change

Statistic	Policy		
	σ_o = 0.017	σ_o = 0.027	σ_o = 0.035
$d \log Y$	3.696	6.957	9.938
$d \log Z$	-1.595	-2.867	-3.926
$vd \log L_s$	1.387	2.760	4.128
$(1-v)\, d \log M_o$	3.904	7.064	9.736
w	2.086	3.779	5.212
M_e	3.766	7.205	10.449
Welfare	-0.088	-0.311	-0.630
C	1.366	2.311	2.968
$1-L_s$	-0.705	-1.415	-2.133

It is worthwhile to consider the role of modeling heterogeneous firms rather than a representative firm. With a representative firm, a lump-sum operating subsidy financed by a lump-sum tax would have no effect on the equilibrium whatsoever, while an output subsidy would. Our quantitative results indicate that, with heterogeneous firms, a decoupled subsidy can be even more distortive with respect to welfare than a coupled subsidy. Thus, especially when analyzing decoupled subsidies, modeling heterogeneous firms with endogenous entry and exit is important.

V. Conclusion

We use a standard general equilibrium model with heterogeneous firms and endogenous entry and exit to contrast the effects of coupled and decoupled subsidies. In this setting, decoupled subsidies have negative effects on TFP that coupled subsidies do not. Decoupled subsidies can also lead to larger welfare losses than coupled subsidies, contrary to conventional wisdom. A caveat to our analysis is that it is less applicable to sectors in which fixed costs of operating are less important. Future research involves using the methodology here to quantitatively account for the effects of subsidy removal or imposition in particular economies and sectors.

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