Optimal Development Policies with Financial Frictions*

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Abstract

We study optimal Ramsey policies in a standard growth model with financial frictions. In the model, heterogeneous entrepreneurs face borrowing constraints which result in a misallocation of capital and reduced labor productivity. In the short-run, the optimal policy intervention suppresses wages and increases labor supply, resulting in higher entrepreneurial profits and faster accumulation of entrepreneurial wealth. This in turn relaxes borrowing constraints in the future, leading to higher labor productivity and wages. This policy is more desirable the more undercapitalized are entrepreneurs and the greater is the extent of misallocation in the economy, both of which are likely to be more acute in developing countries. The rationale for policy intervention is a dynamic pecuniary externality akin to a technological learning-by-doing externality, but instead operating via the misallocation of resources in the presence of financial frictions. In an extension of the model with a tradable and a non-tradable sector, optimal Ramsey policy may result in an undervalued real exchange rate.

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1 Introduction

Is there a role for governments in underdeveloped countries to accelerate economic development by intervening in product and factor markets? Should they use taxes and subsidies? If so, which ones? To answer these questions, we study optimal policy intervention in a standard growth model with financial frictions. In our framework, forward-looking heterogeneous producers face borrowing (collateral) constraints which result in a misallocation of capital and depressed labor productivity. It is therefore similar to the one studied in a number of recent papers relating financial frictions to aggregate productivity (see e.g. Banerjee and Duflo, 2005; Jeong and Townsend, 2007; Quintin, 2008; Amaral and Quintin, 2010; Song, Storesletten, and Zilibotti, 2011; Buera, Kaboski, and Shin, 2011; Buera and Shin, 2013).[1] Our paper is the first to study the implications of Ramsey-optimal policies for a country's development dynamics in such an economy.[2]

We tackle the design of optimal policy using a simple and tractable model, which allows us to obtain sharp analytical characterizations. Our small open economy is populated by two types of agents: a continuum of heterogeneous entrepreneurs and a continuum of homogeneous workers. Entrepreneurs differ in their wealth and their productivity (ability), and borrowing constraints limit the extent to which capital can reallocate from wealthy to productive individuals. In the presence of financial frictions, productive entrepreneurs make positive profits; they then optimally choose how much of these to consume and how much to retain as internal financing to accumulate wealth. Workers decide how much labor to supply to the market and how much to save. Section 2 lays out the structure of the economy and characterizes the decentralized laissez-faire equilibrium.

In equilibrium, marginal products of capital are not equalized, and if a redistribution of capital from unproductive towards productive entrepreneurs were possible, it could be used to construct a Pareto improvement for all entrepreneurs and workers. Our first result, however, is that even much simpler deviations from the decentralized equilibrium result in a Pareto improvement. In Section 3, we provide two examples. The first deviation is a wealth transfer between workers and all entrepreneurs, *independently* of their productivity,

[1] A similar environment has also been studied by Cagetti and De Nardi (2006), and in many of the papers surveyed by Quadrini (2011). The particular formulation we use is based on the tractable formulation in Moll (2012). Also see the early contributions by Banerjee and Newman (1993), Galor and Zeira (1993), Aghion and Bolton (1997) and Piketty (1997), the dynastic frameworks of Erosa and Hidalgo-Cabrillana (2008) and Caselli and Gennaioli (2013), and the recent surveys by Matsuyama (2007) and Townsend (2009).

[2] There are two other papers studying Ramsey problems in related though somewhat different environments, but with completely different focus. Caballero and Lorenzoni (2007) study optimal cyclical policies, i.e. policy responses to aggregate shocks; and Angeletos, Collard, Dellas, and Diba (2013) study optimal liquidity provision (see discussion below).

which reduces the gap between the average return to capital of entrepreneurs and the interest rate available to workers. The second deviation does not even require any transfers at all, and only relies on a coordinated adjustment in labor supply by workers. The key is that increased labor supply reduces wages paid by firms, increases their profits, and allows them to accumulate wealth faster. Greater wealth in the hands of entrepreneurs means that the productive ones among them produce on a larger scale, driving unproductive ones out of business, thereby increasing labor productivity and hence wages.

In Section 4, we explore policy interventions more systematically: we introduce various tax instruments into this economy and study optimal Ramsey policy given the available policy tools. We consider the problem of a benevolent Ramsey planner that seeks to maximize the welfare of workers, and in an extension discussed in Section 6 we consider the case when the planner also puts some Pareto weight on the welfare of entrepreneurs. Importantly, we view the financial friction as a *technological* feature of the economic environment so that the planner faces the same constraints present in the decentralized economy. We first study a relatively simple setup with only three tax instruments, and then show that the results derived there carry over to a more general setting with a much greater number of tax instruments. The three tax instruments in our benchmark exercise are a labor supply subsidy, a savings subsidy for workers and a savings subsidy for entrepreneurs. All of these are financed through a lump-sum tax on workers, and therefore the last instrument is also a vehicle for direct wealth transfers between workers and entrepreneurs.

Our main result is that the optimal policy intervention involves distorting labor supply of workers, but that it looks rather different for developing countries far away from steady state and developed countries close to steady state. In particular, it is optimal to *subsidize* labor supply in the initial transition phase, when entrepreneurs are undercapitalized, but the optimal intervention turns into a labor supply *tax* once the economy comes close enough to the steady state, where entrepreneurs are well capitalized. Intuitively, the short-run labor supply subsidy reduces wages paid by firms, increases their profits, and leads them to accumulate wealth faster. This in turn increases labor productivity and wages in the future, and hence workers end up being better off. The only case in which a short-run wage subsidy is undesirable is if there is no bound on savings subsidies received by entrepreneurs, meaning that the planner can transfer so much wealth from workers to entrepreneurs that the economy reaches its steady state immediately.

While we focus on the labor supply subsidy for concreteness, there are of course many equivalent ways of implementing the optimal allocation. The common feature of such policies is that they increase labor supply in the short run, thereby hurting workers, and that

they increase profits, thereby benefitting entrepreneurs. We show that such *pro-business development policies* are optimal even if the planner puts zero weight on the welfare of entrepreneurs. Even in this case, the planner finds it optimal to hurt workers in the short-run so as to reward them with high wages in the long-run. An alternative way of thinking about this result is that the labor supply decision of workers involves a dynamic pecuniary externality: workers do not internalize the fact that working more leads to higher wealth accumulation by entrepreneurs and higher wages in the future. The planner corrects this using a Pigouvian subsidy. In fact, a reduced form of our setup turns out to be mathematically equivalent to a setup in which production is subject to a learning-by-doing externality, whereby working more today increases future productivity (as in Krugman, 1987).[3] While mathematically equivalent, the economics are quite different: the dynamic externality in our framework is a pecuniary one stemming from the presence of financial frictions and operating via the (mis)allocation of resources, rather than a technological externality.

Section 5 introduces a nontradable sector into the model in order to analyze real exchange rate implications of the Ramsey-optimal policy interventions. The optimal labor supply subsidy in this case turns into a tax on non-tradables, which drives up their price and leads to an appreciated real exchange rate. However, when the planner does not have access to a policy instrument which can discriminate between tradables and non-tradables, the second-best intervention is to tax current consumption, or subsidize savings of workers, which increases labor supply to the tradable sector through both an income effect on the overall labor supply and a reduction in the demand for non-tradable labor.[4] Such policy intervention depresses the wage rate and the price of the non-tradables, thereby leading to a depreciated real exchange rate, a current account surplus and a simultaneous inflow of production capital in the form of FDI or portfolio investments. We point out that the same policy objective of shifting labor towards the tradable sector may result in opposing movements in the real exchange rate, depending on what policy instrument is available to the planner.

We conclude in Section 6 by discussing the various assumptions made in our analysis and provide a number of extensions to the baseline setup.

Related Literature As mentioned in the first paragraph of this introduction, our paper is related to the large theoretical literature studying the role of financial market imperfections

[3] See Korinek and Serven (2010) and Benigno and Fornaro (2012) for recent papers analyzing such setups.

[4] Alternative implementations of such intervention include forced savings by means of financial repression under capital controls.

in economic development, and in particular the more recent literature relating financial frictions to aggregate productivity.[5]

We contribute to this literature by studying the problem of a Ramsey social planner and by working out the resulting implications for a country's transition dynamics. Angeletos, Collard, Dellas, and Diba (2013) study a Ramsey problem in a different, and also highly tractable, setup with heterogeneous producers and financial frictions, but their focus is on optimal public debt management as supply of collateral. In terms of the economic mechanism, our paper is most closely related to the work of Caballero and Lorenzoni (2007) who analyze the Ramsey-optimal response to a cyclical (preference) shock in a two-sector small open economy with financial frictions in the tradable sector. Similarly to our framework, the financial frictions in their work give rise to a pecuniary externality, which justifies a policy intervention that distorts the allocation of resources across sectors. Our focus differs in that we consider long-run development policies in the context of a growth model, and we rely on a different and more tractable formulation of financial frictions, building on Moll (2012).[6]

In terms of methodology, we follow the dynamic public finance literature and study a Ramsey problem (see e.g. Lucas and Stokey, 1983). In particular, we analyze a Ramsey problem in an environment with idiosyncratic risk and incomplete markets as in Aiyagari (1995) and Shin (2006) among others. In contrast to most papers in this literature, however, we are neither concerned with capital taxation (e.g. Chamley, 1986; Judd, 1985; Aiyagari, 1995) or optimal financing of government expenditure and debt management (e.g. Barro, 1979; Lucas and Stokey, 1983).

Finally, there is at least some anecdotal evidence that the sort of policies prescribed in our normative analysis have historically been used in countries with successful development experiences. For example, Kim and Leipziger (1997) state that low labor costs in early stages of development have been instrumental to the rapid development of South Korea, and that this was an official goal of government policy. While examples of active policies explicitly aimed at suppressing wages are somewhat harder to come by, the *absence* of any regulation or policies protecting workers arguably contributed to reduced labor costs in the early stages of Korea's transition. This absence of worker protection is also a pervasive feature in many

[5]These papers are in turn part of a growing literature exploring the macroeconomic effects of micro distortions, in particular their effect on aggregate total factor productivity (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Bartelsman, Haltiwanger, and Scarpetta, 2012). In turn a large literature has argued that cross-country income differences are primarily accounted for by low TFP in developing countries (Hall and Jones, 1999; Klenow and Rodríguez-Clare, 1997; Caselli, 2005).

[6]A related strand of work emphasizes a different type of pecuniary externality that works through prices in borrowing constraints, for example Bianchi and Mendoza (2010), Bianchi (2011), Jeanne and Korinek (2010), Korinek (2011). Yet other types of such externalities are identified in e.g. Caballero and Krishnamurthy (2004) and Lorenzoni (2008).

other developing countries. Besides Korea, examples that come to mind are Japan in the 1950s and 60s and China nowadays.[7] Note, however, that we are by no means advocating the abandonment of worker protection in developing countries. Our framework is completely silent on the exact implementation of the optimal employment allocation, and there are other equivalent implementations like the wage subsidy in our benchmark model.

2 An Economy with Financial Frictions

In this section we describe our baseline economy with financial frictions. We consider a one-sector small open economy populated by two types of agents: workers and entrepreneurs. We setup the economy in continuous time with infinite horizon and no aggregate shocks to focus on the properties of the transition paths. We first describe the problem of workers, followed by that of entrepreneurs. We then characterize some aggregate relationships and the decentralized equilibrium in this economy.

2.1 Workers

The economy is populated by a representative worker with preferences

$$\int_0^\infty e^{-\rho t} u\big(c(t), 1-\ell(t)\big)\mathrm{d}t, \tag{1}$$

where ρ is the discount rate, c is consumption, ℓ is labor supply, and we normalize the overall time endowment to one.[8] We assume that $u(\cdot)$ is increasing and concave in both arguments with a positive and finite Frisch elasticity of labor supply (see Appendix A.1). Where it leads to no confusion, we drop the time index t.

The household takes the market wage $w(t)$ as given, as well as the consumption goods price which we choose as the numeraire. It can borrow and save using non-state-contingent bonds which pay risk free interest rate r^*. As a result, the flow budget constraint of the household is:

$$c + \dot{b} \leq w\ell + r^* b, \tag{2}$$

where $b(t)$ is the household asset position. The solution to the household problem is char-

[7] Also see Cole and Ohanian (2004) and Alder, Lagakos, and Ohanian (2013) who argue that the pervasiveness of unionization had a detrimental effect on development in the United States around the time of the Great Depression.

[8] Alternatively, $(1-\ell)$ can be interpreted as time spent in home production or labor allocation to the non-tradable sector (see Section 5).

acterized by an Euler equation

$$\frac{\dot{u}_c}{u_c} = \rho - r^*, \tag{3}$$

and a static optimality (labor supply) condition:

$$\frac{u_\ell}{u_c} = w, \tag{4}$$

where subscripts denote respective partial derivatives (slightly abusing notation, u_ℓ stands for $\partial u(c, 1-\ell)/\partial(1-\ell)$).

2.2 Entrepreneurs

There is a unit mass of entrepreneurs that produce the homogenous tradable good. Entrepreneurs are heterogeneous in their wealth a and their productivity z, and we denote the joint distribution at time t by $G_t(a, z)$. In each time period of length Δt, entrepreneurs draw a new productivity from a Pareto distribution $G_z(z) = 1 - z^{-\eta}$ with shape parameter $\eta > 1$. We consider the limit economy in which $\Delta t \to 0$, so we have a continuous time setting in which productivity shocks are *iid* over time.[9] Finally, we assume a law of large numbers so the share of entrepreneurs experiencing any particular sequence of shocks is deterministic.

Entrepreneurs have preferences

$$\mathbb{E}_0 \int_0^\infty e^{-\delta t} \log c_e(t) \mathrm{d}t \tag{5}$$

where δ is their discount rate. To ensure existence of a steady state, we assume $\delta > r^*$, however our transition path analysis can be carried out without this assumption. Each entrepreneur owns a private firm which can use k units of capital and n units of labor to produce

$$A(t)(zk)^\alpha n^{1-\alpha}, \tag{6}$$

units of output where $\alpha \in (0, 1)$ and $A(t)$ is aggregate productivity following an exogenous path. Entrepreneurs hire labor in the competitive labor market at wage $w(t)$ and purchase capital in a capital rental market at rental rate r^*. The setup with a rental market is

[9] Moll (2012) shows how to extend the environment to the case where shocks are persistent at the expense of some extra notation and mathematical complication. Persistent shocks generate some additional endogenous dynamics for aggregate total factor productivity, but the qualitative properties of the decentralized equilibrium are otherwise unchanged. They may however have some additional implications for the quantitative properties of the model and the solution to the Ramsey problem which we analyze later. As explained in Moll (2012), an iid process in continuous time can also be viewed as the limit of a mean-reverting process as the speed of mean reversion goes to infinity.

chosen solely for simplicity. As shown by Moll (2012), it is equivalent to a setup in which entrepreneurs own and accumulate capital k and can trade in a risk-free bond.[10] Entrepreneurs face collateral constraints:

$$k \leq \lambda a, \tag{7}$$

where $\lambda \geq 1$ is an exogenous parameter. By placing a restriction on an entrepreneur's leverage ratio k/a, the constraint captures the common prediction from models of limited commitment that the amount of capital available to an entrepreneur is limited by his personal assets.[11] At the same time, the particular formulation of the constraint is analytically convenient and allows us to derive most of our results in closed form. As shown in Moll (2012), the constraint could also be generalized in a number of ways at the expense of some extra notation.[12] Finally, note that by varying $\lambda \in [1, \infty)$, we can trace out all degrees of efficiency of capital markets, with λ therefore capturing the degree of financial development.

An entrepreneur's wealth evolves according to

$$\dot{a} = \pi(a, z) + r^* a - c_e, \tag{8}$$

where $\pi(a, z)$ are his profits

$$\pi(a, z) \equiv \max_{\substack{n \geq 0 \\ 0 \leq k \leq \lambda a}} \left\{ A(zk)^\alpha n^{1-\alpha} - wn - r^* k \right\}$$

Maximizing out the choice of labor, n, profits are linear in capital, k. It follows that the optimal capital choice is at a corner: it is zero for entrepreneurs with low productivity, and the maximal amount allowed by the collateral constraints, λa, for those with high enough productivity. We summarize the solution to entrepreneurs' profit maximization problem in

[10] More precisely, the setup with intertemporal borrowing in a risk-free bond is equivalent to the one with an intratemporal rental market under the assumption that entrepreneurs know their productivity one period in advance. See also Buera and Moll (2012) who analyze such a setup.

[11] The constraint can be derived from the following limited commitment problem. Consider an entrepreneur with wealth a who rents k units of capital. The entrepreneur can steal a fraction $1/\lambda$ of rented capital. As a punishment, he would lose his wealth. In equilibrium, the financial intermediary will rent capital up to the point where individuals would have an incentive to steal the rented capital, implying a collateral constraint $k/\lambda \leq a$ or $k \leq \lambda a$. See Banerjee and Newman (2003) and Buera and Shin (2013) for a similar motivation of the same form of constraint. Note, however, that the constraint is essentially static because it rules out optimal long term contracts (as in Kehoe and Levine, 2001, for example). On the other hand, as Banerjee and Newman put it "there is no reason to believe that more complex contracts will eliminate the imperfection altogether, nor diminish the importance of current wealth in limiting investment."

[12] For example, we could allow the maximum leverage ratio λ to be an arbitrary function of productivity so that (7) becomes $k \leq \lambda(z)a$. The maximum leverage ratio may also depend on the interest rate and wages, calendar time and other aggregate variables. What *is* crucial is that the collateral constraint is linear in wealth.

the following:[13]

Lemma 1 *Factor demands and profits are linear in wealth for active entrepreneurs:*

$$k(a,z) = \lambda a \cdot \mathbf{1}_{\{z \geq \underline{z}\}}, \tag{9}$$

$$n(a,z) = \big((1-\alpha)A/w\big)^{1/\alpha} z k(a,z), \tag{10}$$

$$\pi(a,z) = \big[z/\underline{z} - 1\big] r^* k(a,z), \tag{11}$$

and the productivity cutoff $\underline{z}$ is defined by:

$$\alpha\big((1-\alpha)/w\big)^{\frac{1-\alpha}{\alpha}} A^{1/\alpha} \underline{z} = r^*. \tag{12}$$

Throughout the paper we assume that along all transition paths considered, the productivity cutoff is high enough, specifically $\underline{z} > 1$, that is there always exist entrepreneurs with low enough productivity to be inactive. The marginal entrepreneurs with productivity $\underline{z}$ break even and make zero profits, while entrepreneurs with productivity $z > \underline{z}$ receive Ricardian rents. The labor demand depends on both entrepreneur's productivity and capital choice, with the marginal product of labor equalized across active entrepreneurs. At the same time, the choice of capital among the active entrepreneurs is shaped by the collateral constraint, which depends only on the assets of the entrepreneurs. Therefore, the marginal product of capital on average increases with entrepreneurs' productivity z, reflecting the misallocation of resources in the economy.

Finally, entrepreneurs chose consumption and savings to maximize (5) subject to (8) and (11). Under our assumption of log utility combined with the linearity of profits, there exists an analytic solution to their consumption policy function, $c_e = \delta a$, and therefore the evolution of wealth satisfies (see Appendix A.2):

$$\dot{a} = \pi(a,z) + (r^* - \delta)a, \tag{13}$$

which completes our description.

[13] **Proof**: Equation (10) is the first order condition of profit maximization with respect to n, which substituted into the profit equation results in $\pi(a,z) = \max_{0 \leq k \leq \lambda a} \left\{ \left(\alpha\big((1-\alpha)/w\big)^{(1-\alpha)/\alpha} A^{1/\alpha} z - r^* \right) k \right\}$. Equations (9) and (12) characterize the solution to this problem of maximizing a linear function of k. Using (12), we substitute $\alpha\big((1-\alpha)/w\big)^{(1-\alpha)/\alpha} A^{1/\alpha} = r^*/\underline{z}$ into the expression for profits to obtain (11).

2.3 Aggregate relationships

In this section we provide a number of useful equilibrium relationships. First, aggregating (9) and (10) over all entrepreneurs, we obtain the aggregate capital and labor demand:[14]

$$\kappa = \lambda x \underline{z}^{-\eta}, \tag{14}$$

$$\ell = \frac{\eta}{\eta - 1}\big((1-\alpha)A/w\big)^{1/\alpha}\lambda x \underline{z}^{1-\eta}, \tag{15}$$

where $x(t) \equiv \int a \mathrm{d}G_t(a,z)$ is aggregate (or average) entrepreneurial wealth. Note that we have made use of the assumption that productivity shocks are iid over time which implies that, at each point in time, wealth a and productivity z are independent in the cross-section of entrepreneurs.[15]

Aggregate output in the economy can be characterized by a production function:[16]

$$y = Z\kappa^{\alpha}\ell^{1-\alpha} \qquad \text{with} \quad Z \equiv A\left(\frac{\eta}{\eta-1}\,\underline{z}\right)^{\alpha}, \tag{16}$$

where Z is aggregate total factor productivity (TFP) which is the product of aggregate technology A and the average productivity of active entrepreneurs, $\mathbb{E}\{z|z \geq \underline{z}\} = \eta\underline{z}/(\eta-1)$. Using (14)–(16) together with the productivity cutoff condition (12), we characterize the equilibrium relationship between average wealth x, labor supply ℓ and aggregate output y, as well as express other equilibrium objects as functions of these three variables:[17]

Lemma 2 *Equilibrium aggregate output satisfies:*

$$y = y(x,\ell) \equiv \Theta\, x^{\gamma}\ell^{1-\gamma}, \tag{17}$$

where

$$\Theta \equiv \frac{r^*}{\alpha}\left[\frac{\eta\lambda}{\eta-1}\left(\frac{\alpha A}{r^*}\right)^{\frac{\eta}{\alpha}}\right]^{\gamma} \qquad \textit{and} \qquad \gamma \equiv \frac{\alpha/\eta}{\alpha/\eta + (1-\alpha)}.$$

[14] Specifically, $\kappa(t) = \int k_t(a,z)\mathrm{d}G_t(a,z)$ and $\ell(t) = \int n_t(a,z)\mathrm{d}G_t(a,z)$.

[15] This follows because an entrepreneur chooses his wealth a_t one instant before (at $t - \Delta t$), when he *does not know* his productivity draw z_t. By construction, therefore, a_t is correlated with $z_{t-\Delta t}$ but not with z_t.

[16] Aggregate output equals $y(t) = \int A(t)\big(zk_t(a,z)\big)^{\alpha} n_t(a,z)^{1-\alpha}\mathrm{d}G_t(a,z)$, i.e., integral of individual outputs using production function (6). Aggregate production function (16) combines this definition with aggregate capital and labor demand in (14) and (15).

[17] **Proof**: Combine cutoff condition (12) and labor demand (15) to solve for (18). Substitute the resulting expression (18) and capital demand (14) into aggregate production function (16) to obtain (17). The remaining equation are a result of direct manipulation of (14)–(16) and (18), after noting that aggregate profits are an integral of individual profits in (11) and equal to $\Pi(t) = \kappa(t)/(\eta-1)$.

Productivity cutoff $\underline{z}$ and the division of income in the economy can be expressed as follows:

$$\underline{z}^{\eta} = \frac{\eta\lambda}{\eta - 1}\frac{r^*}{\alpha}\frac{x}{y}, \tag{18}$$

$$w\ell = (1-\alpha)y, \tag{19}$$

$$r^*\kappa = \alpha\frac{\eta - 1}{\eta}y, \tag{20}$$

$$\Pi = \frac{\alpha}{\eta}y, \tag{21}$$

where $\Pi \equiv \int \pi(a,z)\mathrm{d}G_t(a,z)$ are aggregate profits of the entrepreneurs.

Lemma 2 expresses equilibrium aggregates as functions of the state variable x and labor supply ℓ. Note that given (17), both equilibrium wage rate, $w = (1-\alpha)y/\ell$, and productivity cutoff, $\underline{z}$, are increasing functions of a/ℓ. High entrepreneurial wealth, x, increases capital demand and allows a given labor supply to be absorbed by only the more productive entrepreneurs, raising both the average productivity of active entrepreneurs and aggregate labor productivity (hence wages). Greater labor supply, ℓ, requires less productive entrepreneurs become active to absorb it, which on opposite reduces average productivity and wages.[18] Nonetheless, both higher x and higher ℓ lead to an increase in aggregate output and aggregate incomes of all groups in the economy—workers, entrepreneurs and rentiers.

The presence of financial frictions results in active entrepreneurs making positive profits, and therefore a fraction of national income is received by entrepreneurs.[19] Note from Lemma 2 that parameter γ equals the share of profits in the total income of imperfectly-mobile factors, that is labor and entrepreneurial wealth ($\gamma = \Pi/(\Pi + w\ell)$). This parameter measures the severity of the financial frictions and therefore plays a crucial role in the analysis of optimal policies in Section 4.

Finally, integrating (13) across all entrepreneurs, aggregate entrepreneurial wealth evolves according to:

$$\dot{x} = \frac{\alpha}{\eta}y + (r^* - \delta)x, \tag{22}$$

where from Lemma 2 the second term on the right-hand side equals aggregate entrepreneurial profits $\Pi = \alpha y/\eta$. Therefore, greater labor supply increases output, which raises entrepreneurial profits and speeds up wealth accumulation.

[18] Note that the effect of increased labor supply on marginal product of labor through declining productivity, $\underline{z}$, is *partly* offset by the expansion in demand for capital, κ, as can be seen from (14).

[19] This happens at the expense of rentiers, whose share of income falls below α due to the decreased demand for capital in a frictional environment and despite the maintained return on capital of r^*. The share of labor still equals $(1-\alpha)$, as in the frictionless model, where $\gamma = 0$, $y = \Theta\ell$, $\Theta = \left[A(a/r)^{\alpha}\right]^{1/(1-\alpha)}$, $w\ell = (1-\alpha)y$, $r^*\kappa = \alpha y$ and $\Pi = 0$.

2.4 Decentralized Equilibrium

A *competitive equilibrium* in this small open economy is defined in the usual way. That is, taking prices as given, (i) the workers maximize their utility (1) subject to their budget constraint (2); (ii) the entrepreneurs maximize their respective utility (5) subject to their respective budget constraint (8), which involves optimal production decisions; and (iii) the path of the wage rate, $w(t)$, results in the labor market clearing at each point in time, while the capital is in perfectly-elastic supply at interest rate r^*. Given our analysis in the preceding sections, a competitive equilibrium can be summarized as the time path for $\{c(t), \ell(t), b(t), y(t), x(t), w(t), \underline{z}(t)\}_{t\geq 0}$ satisfying (2)–(4) and (17)–(22), given the initial asset position of the household b_0, the initial entrepreneurial wealth x_0, and the path of exogenous productivity $\{A(t)\}_{t\geq 0}$.

3 Inefficiency of Decentralized Equilibrium

In our economy, financial frictions limit the ability of resources to relocate towards the most productive entrepreneurs resulting in the dispersion of the marginal product of capital and inefficiency of the decentralized allocation. However, the equilibrium fails to satisfy much weaker forms of constrained efficiency, which do not require transfers from unproductive towards productive entrepreneurs.

First, consider a transfer between workers and all entrepreneurs independently of their productivity. Availability of such transfer necessarily leads to a Pareto improvement for all agents in the economy because workers and entrepreneurs face different rates of return, which do not equalize in the decentralized equilibrium because of the financial friction. Indeed, the workers face a rate of return r^*, while an entrepreneur with productivity z faces a rate of return $R(z) \equiv r^* \left(1 + \lambda\left[z/\underline{z} - 1\right]^+\right)$, with $R(z) \geq r^*$ for all z and $R(z) > r^*$ for $z > \underline{z}$. Because of the collateral constraint, an entrepreneur with productivity $z > \underline{z}$ cannot expand his capital to drive down his return to r^*. The expected rate of return across entrepreneurs is given by:

$$\mathbb{E}_z R(z) = r^* \left(1 + \frac{\lambda \underline{z}^{-\eta}}{\eta - 1}\right) = r^* + \frac{\alpha}{\eta}\frac{y}{x} > r^*,$$

where the first equality integrates $R(z)$ using the Pareto distribution $G(z)$ and the second equality uses the equilibrium cutoff expression (18). Due to this lack of equalization of returns, a transfer of resources from workers to entrepreneurs at $t = 0$ and a reverse transfer at $T > 0$ with interest accumulated at some rate $\tilde{r}_\beta = r^* + \beta \int_0^T \frac{\alpha}{\eta}\frac{y(t)}{x(t)} \mathrm{d}t$ for some $\beta \in (0, 1)$

necessarily leads to a Pareto improvement for all workers and entrepreneurs.[20]

Yet, the decentralized equilibrium does not satisfy an even weaker form of constrained efficiency, which requires no transfer at all and only a coordinated adjustment in labor supply by households, as we state in:

Proposition 1 *For any decentralized equilibrium, there exists a perturbation to the path of labor supply, without adjustments in other policy functions of the agents, which results in a strict Pareto improvement for all workers and all entrepreneurs.*

We provide a formal proof of this proposition in Appendix A.3 and here offer an intuitive explanation. Recall from Lemma 2 that an increase in labor supply results in lower contemporaneous wages, but greater output and profits and hence faster entrepreneurial wealth accumulation, which in turn increases future productivity and wages. This change in household labor supply can be viewed as a *wage suppression* policy, which is necessarily beneficial for all entrepreneurs, but more surprisingly is also beneficial for the workers in the long run through the dynamic productivity effects. Of course, such perturbation of labor supply is an imperfect substitute to the transfers between households and workers that we discussed above.[21] Therefore, it is quite remarkable that there always exists such an indirect policy intervention which provides a strict Pareto improvement for all agents in the economy.

4 Optimal Ramsey Taxation

In this section we study the optimal interventions with a given set of policy tools. We start our analysis with three tax instruments: a labor subsidy $\varsigma_\ell(t)$, a savings subsidy to workers $\varsigma_b(t)$, and a savings (asset) subsidy to entrepreneurs $\varsigma_x(t)$, all financed by a lump-sum tax on workers. We show that the latter instrument closely reproduces a transfer between workers and entrepreneurs. We then extend our analysis to include additional tax instruments directly affecting the decisions of entrepreneurs, including a subsidy to the cost of capital. We rule out any direct redistribution of wealth *among* entrepreneurs, which would clearly be desirable given the inefficient allocation of capital. Instead, we ask how a planner can improve upon the competitive equilibrium with a limited set of aggregate tax instruments.

[20] We provide a formal argument in Appendix A.3. Note that such a transfer scheme acts effectively as a stock market, which cannot arise in a decentralized equilibrium due to the borrowing constraints.

[21] Indeed, while the transfers help close the gap in the rate of returns, $R(z) - r^*$, at each point in time, increased labor supply open up this gap on impact, but allows to narrow it dynamically. This is because $R(z)$ increases in ℓ and decreases in x.

4.1 Economy with taxes

In the presence of labor and savings subsidies $(\varsigma_\ell, \varsigma_b, \varsigma_x)$, the budget constraints of the agents change from (2) and (8) to:

$$c + \dot{b} \leq w(1 + \varsigma_\ell)\ell + (r^* + \varsigma_b)b - T, \tag{23}$$

$$\dot{a} = \pi(a, z) + (r^* + \varsigma_x)a - c_e, \tag{24}$$

where T are lump-sum taxes that are used to finance $(\varsigma_\ell(t), \varsigma_b(t), \varsigma_x(t))$. Without loss of generality due to the Ricardian equivalence, we assume that the government budget is balanced period-by-period, and therefore:

$$T = \varsigma_\ell w\ell + \varsigma_b b + \varsigma_x x. \tag{25}$$

In the presence of the labor and savings subsidies, the optimality conditions of households (3) and (4) become:

$$\frac{\dot{u}_c}{u_c} = \rho - r^* - \varsigma_b, \tag{26}$$

$$\frac{u_\ell}{u_c} = w(1 + \varsigma_\ell), \tag{27}$$

while the consumption policy function for entrepreneurs remains $c_e = \delta a$.

The following result simplifies considerably the analysis of the optimal policies:[22]

Lemma 3 *Any aggregate allocation* $\{c(t), \ell(t), b(t), x(t)\}_{t\geq 0}$ *satisfying*

$$c + \dot{b} = (1 - \alpha)y(x, \ell) + r^* b - \varsigma_x x, \tag{28}$$

$$\dot{x} = \frac{\alpha}{\eta} y(x, \ell) + (r^* + \varsigma_x - \delta)x, \tag{29}$$

and transversality conditions, where $y(x, \ell)$ *is defined in* (17)*, can be supported as a competitive equilibrium under appropriately chosen policies* $\{\varsigma_\ell(t), \varsigma_b(t), \varsigma_x(t)\}_{t\geq 0}$*, and the equilibrium characterization in Lemma 2 still applies.*

Therefore, we can substitute the problem of choosing the path of the policy tools by the

[22] **Proof:** The introduced policy instruments do not directly affect the static choices (profit maximization) of entrepreneurs given their wealth a, productivity z, and wage rate w, and therefore the aggregation results in Lemma 2 still apply, which we use to express out the aggregate wage bill and entrepreneurial profits as functions of output. With a proportional subsidy to assets, $c_e = \delta a$ is still optimal, and therefore aggregate entrepreneurial wealth must satisfy (29). Combining (23) and (25) results in (28), and any allocation $\{c, \ell\}_{t\geq 0}$ satisfying (28) and a transversality condition can be supported by an appropriate choice of $\{\varsigma_b, \varsigma_\ell\}_{t\geq 0}$.

problem of choosing a dynamic aggregate allocation satisfying (28) and (29). Lemma 2, which still applies in this environment, allows us to back out from the dynamic path of ℓ and x other aggregate variables supporting the allocation, including the productivity cutoff and wages. Equations (28) and (29) are the respective aggregate budget constraints of workers and entrepreneurs, in which we have substituted the government budget constraint (25) and the expressions for aggregate wage bill and profits as a function of aggregate income (output) from Lemma 2. The additional two constraints on the equilibrium allocation are the optimality conditions of workers, (26) and (27), but they can always be ensured to hold by an appropriate choice of labor and savings subsidies for workers.

Finally, note from (28)–(29) that the asset (savings) subsidy for entrepreneurs, $\varsigma_x x$, financed by a lump-sum tax on workers, acts as a tool for redistributing wealth from workers to entrepreneurs (or vice versa when $\varsigma_x < 0$). In fact, the asset subsidy is essentially equivalent to a lump-sum transfer from workers to entrepreneurs, as it does not distort the policy functions of either workers or entrepreneurs. The only difference with a lump-sum transfer is that a proportional subsidy to assets does not affect the consumption policy rule of the entrepreneurs, in contrast to a lump-sum transfer which makes the savings decision of entrepreneurs analytically intractable.[23] In what follows we refer to ς_x as *transfers* to emphasize that it is a very direct tool for wealth redistribution between entrepreneurs and workers.

4.2 Optimal policies without transfers

We now describe the planner's problem in the absence of transfers (asset subsidy to entrepreneurs), that is under the restriction that $\varsigma_x \equiv 0$. This allows us to isolate most clearly the forces that shape optimal labor and savings subsidies to workers. In Section 4.3 we relax this assumption to show the qualitative robustness of our findings to the presence or absence of transfers.

We assume that the planner maximizes the welfare of households and puts zero weight on the welfare of entrepreneurs. As will become clear, this is the most conservative benchmark for our results, and we relax this limiting assumption later. The Ramsey problem in this case is to choose policies $\{\varsigma_\ell(t), \varsigma_b(t)\}_{t\geq 0}$ to maximize household utility (1) subject to the resulting allocation being a competitive equilibrium. From Lemma 3, this problem is equivalent to maximizing (1) with respect to aggregate allocation $\{c(t), \ell(t), b(t), x(t)\}_{t\geq 0}$ subject to (28)–

[23]The savings rule of entrepreneurs stays unchanged when lump-sum transfers are unanticipated. In this case the savings subsidy and lump-sum transfers are exactly equivalent, however, the assumption of unanticipated lump-sum transfers is unattractive for several reasons.

(29) after imposing $\varsigma_x \equiv 0$, which we reproduce as:

$$\max_{\{c,\ell,b,x\}_{t\geq 0}} \int_0^\infty e^{-\rho t} u(c, 1-\ell) \mathrm{d}t \tag{P1}$$

$$\text{subject to} \qquad c + \dot{b} = (1-\alpha) y(x,\ell) + r^* b, \tag{30}$$

$$\dot{x} = \frac{\alpha}{\eta} y(x,\ell) + (r^* - \delta) x, \tag{31}$$

and given initial b_0 and x_0. (P1) is a standard optimal control problem with controls (c, ℓ) and states (b, x), and we denote the corresponding co-state vector by $(\mu, \mu\nu)$. To ease the characterization of the solution and ensure the existence or a finite steady state, in what follows we assume

$$\delta < \rho = r^*, \tag{C1}$$

however, neither first inequality, nor second equality are essential for the pattern of optimal policies along the transition path, which is our focus.

Before characterizing the solution to (P1), we provide a brief discussion of the nature of this planner's problem. Apart from the Ramsey interpretation that we adopt as the main one, this planner's problem admits two additional interpretations. First, it corresponds to the planner's problem adopted in Caballero and Lorenzoni (2007), which rules out any transfers or direct interventions into the decisions of agents, and only allows for aggregate market interventions which affect agent behavior by moving equilibrium prices (wages in our case). Second, the solution to this planner's problem is a constrained efficient allocation under the definition developed in Dávila, Hong, Krusell, and Ríos-Rull (2012) for economies with exogenously incomplete markets and borrowing limits, as ours, where standard notions of constrained efficiency are hard to apply. Under this definition, the planner can choose policy functions for all agents respecting, however, their budget sets and exogenous borrowing constraints. We show in Appendix A.9 that in our case the planner does not want to change the policy functions of entrepreneurs, but chooses to manipulate the policy functions of households exactly in the way prescribed by the solution to (P1). As we show in later sections, the baseline structure of the planner's problem (P1) is maintained in a number of extensions we consider.

By examining (P1), we observe that the planner has no reason to distort the worker's choice of c, but there are two reasons to distort their choice of ℓ. First, the workers take wages as given and do not internalize that $w = (1-\alpha) y/\ell$ (see Lemma 2), that is, by restricting labor supply the workers can increase their wages. As the planner only cares about the welfare of workers, this *monopoly effect* forces the planner to reduce labor supply. Second,

the workers do not internalize the positive effect of their labor supply on entrepreneurial profits and wealth accumulation, which affects future outputs and wages. This *dynamic productivity* effect through wealth accumulation forces the planner to increase labor supply. The interaction between this two effects shapes the optimal policy of the planner, which we now characterize more formally.

The optimality conditions for (P1) can be simplified to yield:[24]

$$\frac{\dot{u}_c}{u_c} = \rho - r^* = 0, \tag{32}$$

$$\frac{u_\ell}{u_c} = \big(1 - \gamma + \gamma\nu\big) \cdot (1-\alpha)\frac{y}{\ell}, \tag{33}$$

$$\dot{\nu} = \delta\nu - \big(1 - \gamma + \gamma\nu\big)\frac{\alpha}{\eta}\frac{y}{x} \tag{34}$$

An immediate implication of (32) is that the planners does not distort the intertemporal margin and the consumption path still satisfies the Euler equation (3). There is no need to distort consumption smoothing since holding labor supply constant consumption does not have a direct effect on wages and productivity. In terms of implementation, this requires no use of the savings subsidy to workers, $\varsigma_b \equiv 0$.

In contrast, the decentralized allocation of labor according to the labor supply condition (4) is in general suboptimal. Indeed, combining planner's optimality (33) with (19) and (27), the *labor wedge* (subsidy) can be expressed in terms of the co-state ν:

$$\varsigma_\ell \equiv -\gamma + \gamma\nu. \tag{35}$$

Whether labor supply is subsidized or taxed depends on whether ν is greater than one, which emphasizes the interaction between the two forces outlined above. Statically optimal monopolistic labor tax equals γ (i.e., $\varsigma_\ell = -\gamma$). The offsetting force is the dynamic productivity gain from increased labor supply, which is reflected by the second term, $\gamma\nu > 0$, in (35). When entrepreneurial wealth is scarce, its shadow value for the planner is high ($\nu > 1$), and the planner subsidizes labor.[25]

We rewrite the optimality conditions (33) and (34), replacing the co-state ν with the

[24]The present-value Hamiltonian for (P1) is given by:

$$\mathcal{H} = u(c, 1-\ell) + \mu\big[(1-\alpha)y(x,\ell) + r^* b - c\big] + \mu\nu\big[\alpha y(x,\ell)/\eta + (r^* - \delta)x\big].$$

The optimality for c and b, $\mathcal{H}_c = 0$ and $\dot{\mu} - \rho\mu = -\mathcal{H}_b$, under parameter restriction (C1) result in (32). (33) and (34) correspond to the optimality with respect to ℓ and x, $\mathcal{H}_\ell = 0$ and $\dot{\nu} - \rho\nu = -\mathcal{H}_x$, which we simplify using the properties of $y(\cdot)$ given in (17) and the definition of γ.

[25]Recall that γ is a measure of the distortion arising from the financial frictions, and in a frictionless economy with $\gamma = 0$, the planner does not need to distort any margin.

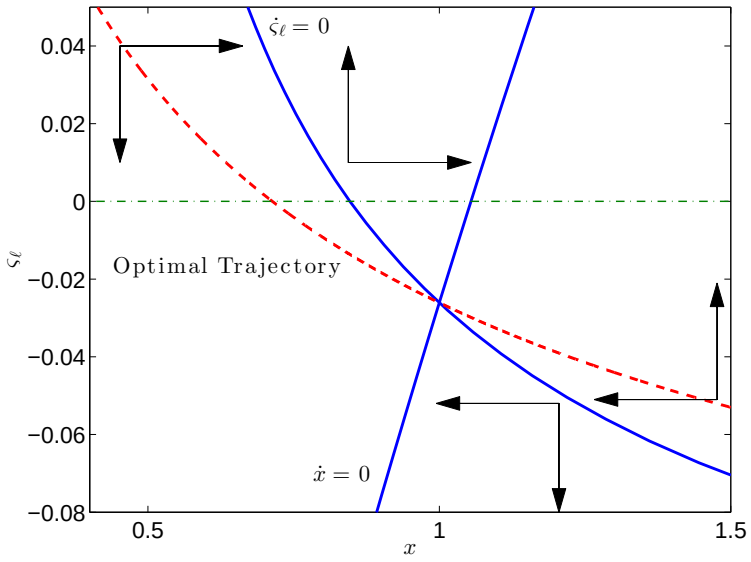


Figure 1: Planner's allocation: phase diagram for transition dynamics

labor wedge ς_ℓ, which are tied by the liner relationship (35):

$$\frac{u_\ell}{u_c} = (1+\varsigma_\ell)\cdot(1-\alpha)\frac{y(x,\ell)}{\ell}, \tag{36}$$

$$\dot{\varsigma}_\ell = \delta(\varsigma_\ell+\gamma) - \gamma\,(1+\varsigma_\ell)\,\frac{\alpha}{\eta}\frac{y(x,\ell)}{x} \tag{37}$$

The planner's allocation $\{c,\ell,b,x\}_{t\geq 0}$, that is solution to (P1), satisfies (30)–(32) and (36)–(37). With $r^* = \rho$, the marginal utility of consumption is constant over time, $u_c(t) = \mu(t) = \bar{\mu}$ for all t, and the system separates in a convenient way. Given a level of $\bar{\mu}$, the optimal labor wedge can be characterized by means of two ODEs in (ς_ℓ, x), (31) and (37), together with the static optimality condition (36). These can be analyzed with standard tools.

Proposition 2 *The solution to the planner's problem* (P1) *corresponds to the globally stable saddle path of the ODE system* (31) *and* (37)*, as summarized in Figure 1. In particular, starting from $x_0 < \bar{x}$, $x(t)$ increases and $\varsigma_\ell(t)$ decreases over time towards the unique positive steady state $(\bar{\varsigma}_\ell, \bar{x})$, with labor supply taxed in steady state:*[26]

$$\bar{\varsigma}_\ell = -\frac{\gamma}{\gamma + (1-\gamma)(\delta/\rho)} < 0. \tag{38}$$

Labor supply is subsidized, $\varsigma_\ell(t) > 0$, when entrepreneurial wealth, $x(t)$, is low enough. The planner does not distort the workers' intertemporal margin, $\varsigma_b(t) \equiv 0$.

[26] (38) follows from (31) and (37) evaluated in steady state (for $\dot{x} = \dot{\nu} = 0$). Using the definition of $y(\cdot)$, steady-state versions of (31), (36) and $u_c \equiv \bar{\mu}$ determine $(\bar{x}, \bar{\ell}, \bar{c})$ as a function of $\bar{\mu}$, which is then recovered as a fixed point from the intertemporal budget constraint of the households.

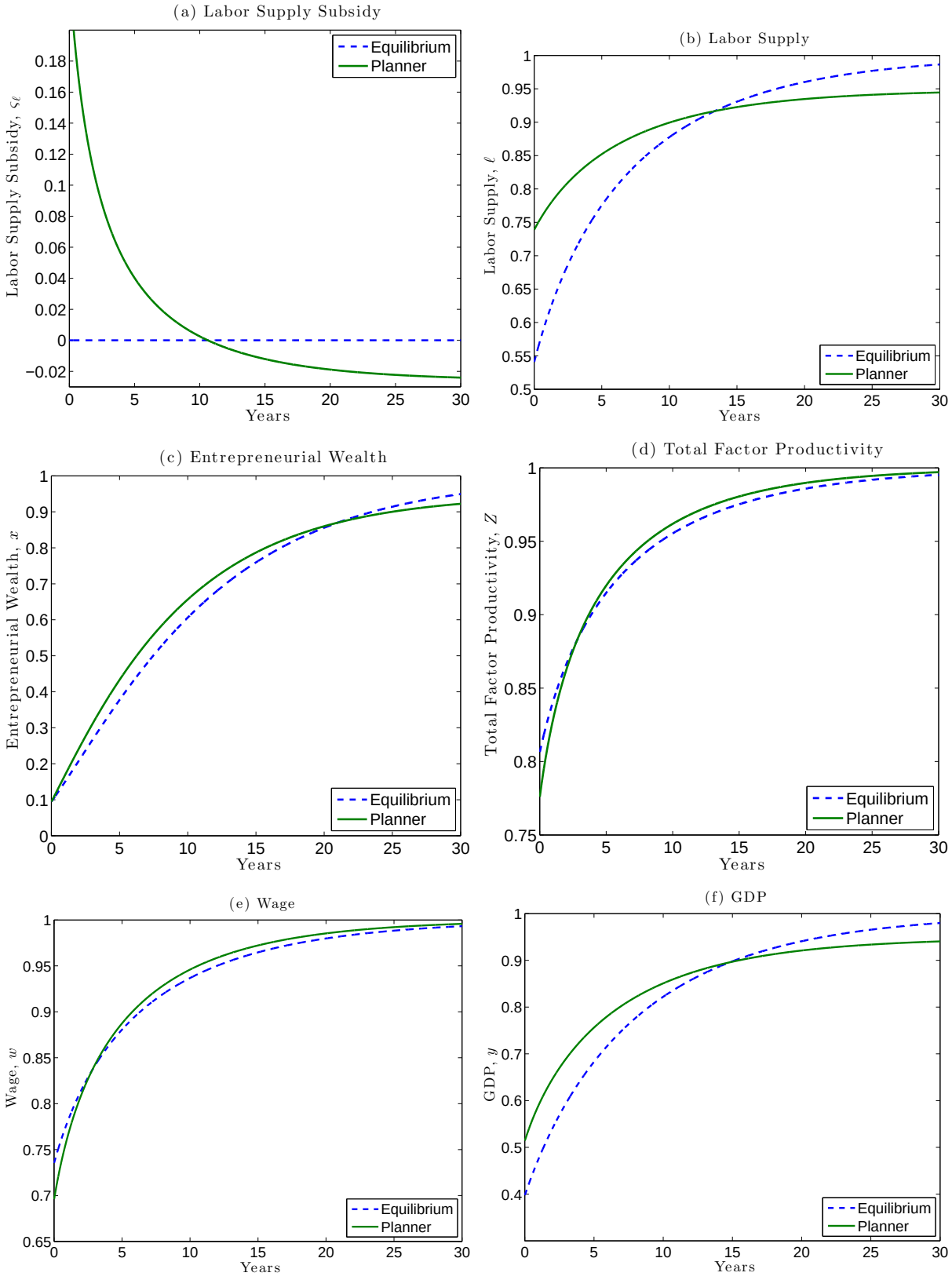


Figure 2: Planner's allocation: time paths of key variables

The optimal steady state labor wedge is strictly negative, meaning that in the long-run the planner implicitly taxes labor supply rather than subsidizing it. This tax is however smaller than the optimal *monopoly tax* equal to γ (i.e., $\bar{\varsigma}_\ell \in (-\gamma, 0)$), because with $\delta > r^*$ the entrepreneurial wealth accumulation is bounded and the financial friction is never resolved (i.e., the shadow value of wealth accumulation is positive, $\bar{\nu} > 0$). Nonetheless, in steady state the redistribution force necessarily dominates the dynamic productivity considerations. This, however, is not the case along the entire transition path to steady state, as we prove in Proposition 2 and as can be seen from the phase diagram in Figure 1. Consider a country that starts out with entrepreneurial wealth considerably below its steady-state level, i.e. in which entrepreneurs are initially severely undercapitalized. Such a country finds it optimal to subsidize labor supply during the initial transition phase, until entrepreneurial wealth reaches a high enough level.

Figure 2 displays transition dynamics for key variables, comparing the allocation chosen by the planner to the one that would obtain in a decentralized equilibrium.[27] Panel (a) of the figure plots the evolution of the optimal labor wedge. It starts out positive, meaning that the planner would like to subsidize considerably labor supply. It then decreases gradually over time, turning negative, until it reaches the optimal steady state labor wedge characterized by (38). This time path for the labor wedge immediately implies the time path for labor supply in panel (b): initially, labor supply chosen by the planner is higher than in the decentralized equilibrium, but steady state labor supply is lower. Panel (c) displays the time path for entrepreneurial wealth: in early stages of the transition, the planner's increased allocation of labor towards the tradable sector stimulates entrepreneurial wealth accumulation; but in later stages entrepreneurial wealth drops below that in the decentralized equilibrium due to the tax on labor supply.

Finally, panels (d) to (f) plot the time paths for Total Factor Productivity, wages, and GDP (aggregate income). Note in particular that the planner's allocation of resources results in Total Factor Productivity that is higher than that in the decentralized equilibrium for most of the transition, apart from the early stages where increased labor supply results in decreased productivity, as we discussed following Lemma 2. The same is true for wages. In contrast, GDP—and hence the total wage bill and demand for capital, as follows from Lemma 2—are higher on impact and during the early stages of transition, but lower in the steady state.

[27] For this numerical example, we assume that workers have GHH utility functions $u(c, 1-\ell) = U(c - v(\ell))$, where $U(\cdot)$ is strictly increasing and concave and $v(\ell) = \ell^{1+1/\varepsilon}/(1+1/\varepsilon)$ with $\varepsilon \in (0, \infty)$. We use the following parameter values which are chosen solely for illustrative purposes: $\alpha = 0.3, \eta = 2, \varepsilon = 2, r^* = \rho = 0.025, \delta = 0.2, \lambda = 1.5, A = 1$ and an initial condition $x(0) = 0.1 \times \bar{x}$.

Implementation The constrained optimal allocation can be implemented in a number of different ways. The way we set up the problem, it is implemented with a subsidy to labor supply financed through a lump-sum tax on workers. In this case, workers' gross labor income including the subsidy is $(1+\varsigma_\ell)(1-\alpha)y(x,\ell)$ and net income after subtracting the lump-sum tax is $(1-\alpha)y(x,\ell)$. Note that increasing labor supply unambiguously increases net labor income but decreases the net hourly wage. An equivalent implementation is to give a wage bill subsidy to firms financed by a lump-sum tax on workers. In this case, the equilibrium wage rate increases to $(1+\varsigma_\ell)(1-\alpha)y(x,\ell)/\ell$, but the firms pays only a fraction of the wage bill, and the resulting allocation is the same. An alternative way of implementing the optimal labor supply path would be through "forced labor"—a forced increase in the hours worked relative to the competitive equilibrium. Such non-market implementation forces workers off their labor supply schedule and the wage is determined by moving along the labor demand schedule of the business sector. This is why we refer to the policy of subsidizing labor supply as a *pro-business* policy, or *wage suppression* policy.[28]

Learning-by-doing externality One alternative way of looking at the planner's problem (P1) is to note that from (17), GDP depends on current labor supply $\ell(t)$ and entrepreneurial wealth $x(t)$. But from (22), entrepreneurial wealth accumulates as a function of past profits, which are a constant fraction of past aggregate incomes, or outputs. Therefore, current output depends on the entire history of past labor supplies, $\{\ell(t)\}_{t\geq 0}$ and the initial level of wealth, $x(0)$. As a result, this setup is equivalent at the aggregate to a neoclassical growth model in which productivity is a function of past labor supplies, and hence is a special case of a general formulation with learning-by-doing externality in production (see, for example, Benigno and Fornaro, 2012). The detailed micro-structure of our environment both provides a discipline for the aggregate planning problem, but also differs in qualitative ways from an environment with a learning by doing. In particular, we now switch to the characterization of optimal policies in the presence of transfers, which are a powerful tool in our environment, but have no bite in an economy with learning by doing.

4.3 Optimal policy with transfers

We now show that the conclusions obtained in the previous section, in particular that optimal Ramsey policy involves a labor subsidy if entrepreneurial wealth is low, are robust to allowing

[28] In an extension described in Appendix A.11, we consider a model with collective bargaining over wages, where a pro-business policy favored in the initial phase of development consists of reducing the bargaining power of workers.

for transfers as long as these are constrained to be finite. We extend the planner's problem (P1) to allow for the asset (savings) subsidy to entrepreneurs, ς_x, financed by a lump-sum tax on workers. The planner now chooses a sequence of three subsidies, $\{\varsigma_b, \varsigma_\ell, \varsigma_x\}_{t\geq 0}$ to maximize household utility (1) subject to the resulting allocation being a competitive equilibrium. We again make use of Lemma 3, which allows us to recast this problem as the one of choosing a dynamic allocation $\{c, \ell, b, x\}_{t\geq 0}$ and a sequence of transfers $\{\varsigma_x\}_{t\geq 0}$ which satisfy household budget constraint (28) and aggregate wealth accumulation equation (29).

We impose an additional constraint on the aggregate transfer:

$$s \leq \varsigma_x(t)\, x(t) \leq S, \tag{39}$$

where $s \leq 0$ and $S \geq 0$. The previous section analyzed the special case of $s = S = 0$. The case with unrestricted transfers corresponds to $S = -s = +\infty$, which we consider as a special case now, but in general allow s and S to be bounded. We find the focus on the constraint on the aggregate transfer, $\varsigma_x x$, rather than the subsidy rate, ς_x, to be more realistic as aggregate transfers from workers to entrepreneurs are likely to be limited by political economy consideration. However, the analysis of the alternative case is almost identical and we leave it out for brevity.[29]

We reproduce the planning problem in this case as:

$$\max_{\substack{\{c,\ell,b,x\}_{t\geq 0},\\ \{\varsigma_x:\ s\leq \varsigma_x x\leq S\}_{t\geq 0}}} \int_0^\infty e^{-\rho t} u(c, 1-\ell)\mathrm{d}t \tag{P2}$$

$$\text{subject to} \qquad c + \dot{b} = (1-\alpha) y(x,\ell) + r^* b - \varsigma_x x,$$
$$\dot{x} = \frac{\alpha}{\eta} y(x,\ell) + (r^* + \varsigma_x - \delta) x,$$

given the initial conditions b_0 and x_0. We still denote the two co-states by μ and $\mu\nu$. Appendix A.4 sets up the Hamiltonian for (P2) and provides the full set of equilibrium conditions, following the same steps outlined in footnote 24. In particular, the optimality conditions (32)–(34) still apply, but now with two additional complementary slackness conditions:[30]

$$\nu \geq 1, \quad \varsigma_x x \leq S \qquad \text{and} \qquad \nu \leq 1, \quad \varsigma_x x \geq s. \tag{40}$$

This has two immediate implications. First, as before, the planner never distorts the

[29] Indeed, it is straightforward to generalize (39) to allow s and S to be functions of aggregate wealth, $x(t)$, in particular to accommodate the special case of the constraint $\underline{\varsigma}_x \leq \varsigma_x(t) \leq \bar{\varsigma}_x$.

[30] Note that the extra terms in the optimality condition (34) for $\dot{\nu}$ cancel out when the complementary slackness conditions (40) are taken into account.

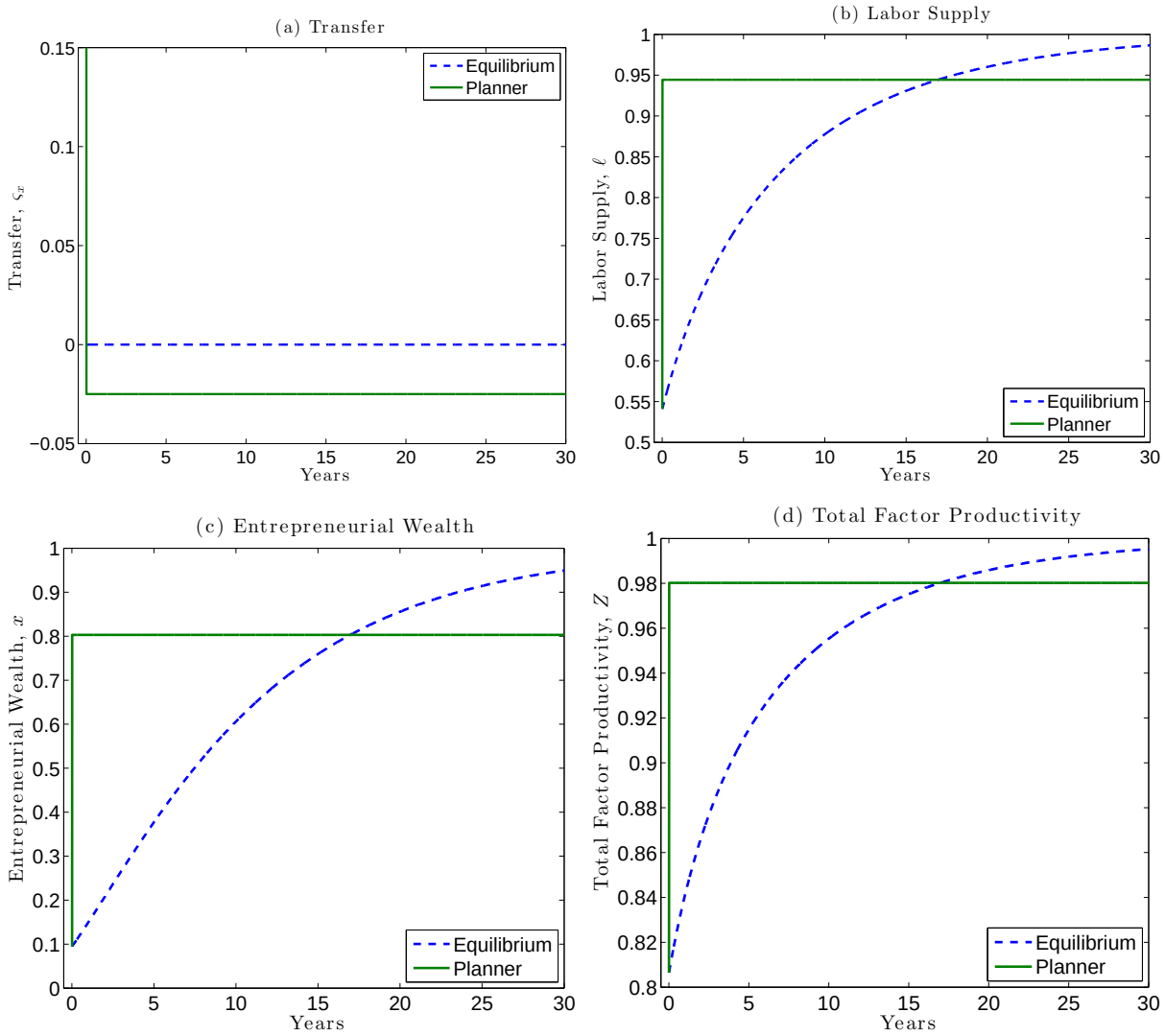


Figure 3: Planner's allocation with unlimited transfers

intertemporal margin of workers, that is $\varsigma_b \equiv 0$. Second, whenever the bounds on transfer are slack, $s < \varsigma_x x < S$, the co-state for the wealth accumulation constraint is unity, $\nu = 1$. In particular, this is always the case when transfers are unbounded, $S = -s = +\infty$. Note that $\nu = 1$ means that the planner's shadow value of wealth, x, equals $\bar{\mu}$—the shadow value of extra funds in the household budget constraint—which is intuitive given the presence of transfers between the two groups of agents in case when transfers are not constrained. From (33) and (35), $\nu = 1$ immediately implies that the labor supply condition is undistorted, that is $\varsigma_\ell = 0$.[31] This discussion allows us to characterize the planner's allocation when

[31]Note that when transfers are unbounded, (P2) can be replaced with a simpler optimal control problem with a single state variable $m \equiv b + x$ and one aggregate dynamic constraint:

$$\dot{m} = \big(1 - \alpha + \alpha/\eta\big) y(x, \ell) + r^* m - \delta x - c.$$

The choice of x in this case becomes static, maximizing the right-hand side of the dynamic constraint at

unbounded transfers are available (see illustration in Figure 3):

Proposition 3 *In the presence of unbounded transfers ($S = -s = +\infty$), the planner distorts neither intertemporal consumption choice, nor intratemporal labor supply along entire transition path: $\varsigma_b(t) = \varsigma_\ell(t) = 0$ for all t. The steady state is achieved in one instant, at $t = 0$, and the steady state asset subsidy equals $\varsigma_x(t) = \bar{\varsigma}_x = -r^*\bar{x}$ for $t > 0$, i.e. a transfer of funds from entrepreneurs to workers. When $x(0) < \bar{x}$, the planner makes an unbounded transfer from workers to entrepreneurs at $t = 0$, i.e. $\varsigma_x(0) = +\infty$, to ensure $x(0+) = \bar{x}$.*[32]

Clearly, the requirement of an unbounded transfer in the initial period is an artifact of the continuous time environment. In discrete time, the required transfer is simply the difference between initial and steady state wealth, which however can be very large if the economy starts far below its steady state in terms of entrepreneurial wealth. Even if we do not take the unbounded transfers in continuous time literally, there is a variety of reasons why such redistributive transfers may be limited in reality. For example, large transfers from workers to entrepreneurs may be infeasible for political economy reasons. Or alternatively, unmodeled distributional concerns may make large transfers (which are large lump-sum taxes from the point of view of workers) undesirable or infeasible (see Werning, 2007).[33] We next study the case when the possible transfers between workers and entrepreneurs are bounded.

For brevity, we consider here the case in which $S < \infty$, but the lower bound is not binding, that is $s \leq -r^*\bar{x}$, while Appendix A.4 presents the general case. The planner's allocation in this case is characterized by $u_c = \bar{\mu}$, (29), (33), (34) and (40), and the transition dynamics has two phases. In the first phase, $x(t) < \bar{x}$, $\nu(t) > 1$ (equivalently, $\varsigma_\ell(t) > 0$) and the planner makes maximal possible transfer from workers to entrepreneurs each period, $\varsigma_x(t)x(t) = S$. During this phase, the characterization is the same as in Proposition 2, but with the difference that a transfer S is added to the entrepreneurs' wealth accumulation constraint (31) and subtracted from the workers' budget constraint (30). That is, starting from $x(0) < \bar{x}$, over time entrepreneurial assets accumulate and the planner distorts labor supply upwards at a decreasing rate: $x(t)$ increases, and $\varsigma_\ell(t) > 0$ and decreases. The second phase is reached in finite time (denote $\bar{t} > 0$) and corresponds to a steady state described in

each point in time, and the choice of labor supply can be immediately seen to be undistorted. The results of Proposition 3 can be obtained directly from this simplified formulation (see Appendix A.4).

[32] Steady state entrepreneurial wealth is determined from (29) substituting in $\bar{\varsigma}_x$: $\delta = \alpha/\eta \cdot y(\bar{x}, \bar{\ell})/\bar{x}$, together with (33) substituting in $\nu = 1$, and given the value of $u_c = \bar{\mu}$ (see footnote 26).

[33] Another unmodeled argument is the dynamic incentive compatibility of entrepreneurs, which may impose limits on sustainable transfers between entrepreneurs and workers. In the present framework the incentive compatibility constraint is static (see footnote 11), and hence is not affected by either future taxes on labor supply, or future asset taxation of entrepreneurs, which acts as transfers to workers.

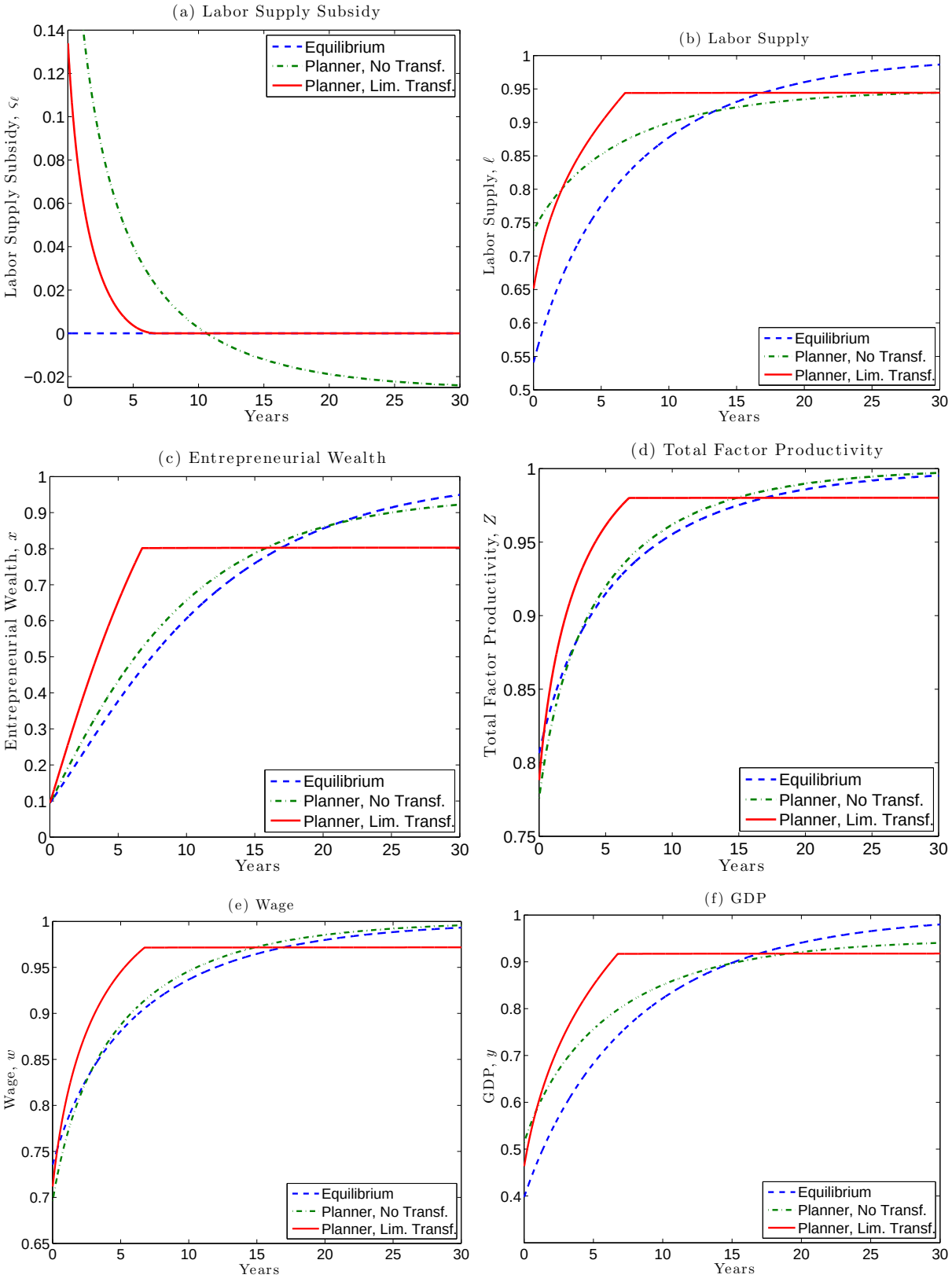


Figure 4: Planner's allocation with limited transfers

Proposition 3: $x(t) = \bar{x}$, $\nu(t) = 1$, $\varsigma_\ell(t) = 0$ and $\varsigma_\ell(t) = -r^*\bar{x}$ for all $t \geq \bar{t}$. Note that during the first phase $\varsigma_\ell(t)$ decreases gradually towards zero, and therefore there is no discontinuity in the optimal labor supply wedge, but the planner switches from a positive to a negative transfer (for entrepreneurs) when steady state is reached. Throughout the entire allocation the intertemporal margin of workers is again not distorted, $\varsigma_b(t) = 0$ for all t.

We illustrate the dynamic planner's allocation in this case in Figure 4 and summarize its properties in the following:

Proposition 4 *Consider the case with $S < \infty$, $s < -r^*\bar{x}$, and $x(0) < \bar{x}$. Then there exists $\bar{t} \in (0, \infty)$ such that: (1) for $t \in [0, \bar{t})$, $\varsigma_x(t)x(t) = S$ and $\varsigma_\ell(t) > 0$, with the dynamics of $\big(x(t), \varsigma_\ell(t)\big)$ described by a pair of ODEs (29) and (37) together with a static equation (36), with a globally-stable saddle path as described in Proposition 2; (2) for $t \geq \bar{t}$, $x(t) = \bar{x}$, $\varsigma_\ell(t) = 0$ and $\varsigma_x(t) = -r^*\bar{x}$, corresponding to the steady state described in Proposition 3. For all $t \geq 0$, $\varsigma_b(t) = 0$.*

We conclude that our main result that optimal Ramsey policy involves a labor supply subsidy if entrepreneurial wealth is low is robust to allowing for transfers as long as these transfers are bounded.[34] Applying this logic to a discrete-time environment, whenever the transfers cannot be large enough to jump entrepreneurial wealth immediately to its steady state level (and therefore its shadow value $\nu > 1$ over a period of time), optimal policy involves a subsidy to labor along the transition phase.

4.4 Other tax instruments

We close this section with a brief discussion of additional tax instruments which directly influence the decisions of entrepreneurs. Specifically, in addition to asset subsidy (ς_x), we introduce a profit subsidy (ς_π), a revenue subsidy (ς_y), a wage-bill subsidy (ς_w), and a capital subsidy (ς_k), all financed by a lump-sum tax on households, so that the budget set of the entrepreneurs is now given by:

$$\begin{aligned} \dot{a} &= (1 + \varsigma_\pi)\pi(a, z) + (r^* + \varsigma_x)a - c_e, \qquad (41) \\ \pi(a, z) &= \max_{\substack{n \geq 0, \\ 0 \leq k \leq \lambda a}} \Big\{(1 + \varsigma_y)A(zk)^\alpha n^{1-\alpha} - (1 - \varsigma_w)w\ell - (1 - \varsigma_k)r^*k\Big\}, \end{aligned}$$

[34] If the lower bound on transfers, s, were also binding, the steady state would also involve a labor supply tax, as we discuss in Appendix A.4.

and the entrepreneurs' consumption-saving decision still satisfies $c_e = \delta a$. In the presence of these additional subsidies to entrepreneurs, the equilibrium characterization in Lemma 2 no longer applies and needs to be generalized, as we do in Appendix A.6. Nonetheless, the output function still exists,

$$y(x,\ell) = \left(\frac{1+\varsigma_y}{1-\varsigma_k}\right)^{\gamma(\eta-1)} \Theta x^{\gamma}\ell^{1-\gamma},$$

with γ and Θ defined as before. Furthermore, the planner's problem has a similar structure to (P1) and (P2) with the added optimization over the choice of the additional subsidies.

We prove in Appendix A.6 the following:

Proposition 5 (a) *When unbounded, the profit subsidy ς_π and the asset subsidy ς_x are equivalent, act as transfers between workers and entrepreneurs, and dominate other policy instruments (which are not used).* (b) *The wage subsidy ς_w is equivalent to the labor supply subsidy ς_ℓ. The combined policy $\varsigma_y = -\varsigma_k = -\varsigma_w$ is equivalent to a profit subsidy. The available tax instruments are used to approximate the effect of a profit subsidy (transfer).*

The profit subsidy, just like the asset subsidy, under log utility does not affect the policy rules of the entrepreneurs, and therefore acts as a transfer between workers and entrepreneurs. When either of these instruments is available and unbounded, Proposition 3 applies and other taxes are not used. A revenue subsidy can be combined with taxes on capital and labor to replicate the effect of a profit subsidy. The effects of ς_y are similar to those of ς_w (which is equivalent to ς_ℓ), however, not identical, as ς_y leads to a larger increase in entrepreneurial revenues and profits for a given increase in labor supply. The effects of ς_k are quite different from those of ς_w, as ς_k increases entrepreneurial profits by means of distorting the extensive margin of active entrepreneurs. The overall conclusion is that whenever an unbounded transfer between workers and entrepreneurs cannot be engineered, there is a period of transition during which all available policy instruments are used to speed up the accumulation of entrepreneurial wealth in the least distortive way.[35]

[35]Using planner's problem (P4), set up in Appendix A.6, one can show that when only ς_y and ς_w are available, the planner sets $\varsigma_y = -\varsigma_w \propto (\nu - 1)$. Similarly, when only ς_k and ς_w are available, the planner sets $\varsigma_k = \varsigma_w \propto (\nu - 1)$. In both cases, ν gradually declines during transition, similar to the patterns described in Proposition 2. In the next versions of the draft we will provide a comparison of effectiveness of ς_y, ς_w and ς_k when each of these instruments is used alone.

5 Nontradables and the Real Exchange Rate

In this section we reinterpret our framework to feature two sectors – a tradable sector with financially constrained entrepreneurs and a frictionless non-tradable sector. Although very stylized, the advantage of this formulation is that it maps directly into our setup of Section 2 without any adjustment to the modeling structure. Furthermore, it is a realistic first approximation if one thinks of the non-tradable sector as less capital intensive and with firms operating on a smaller scale, hence less subject to financing constraints (an assumption adopted also in Caballero and Lorenzoni, 2007). We present this reinterpretation of our framework for illustrative purposes here and provide the full treatment of a multisector environment with all sectors subject to financial constraints in a follow up paper.

Specifically, we think of an environment with workers having utility over tradable and non-tradable goods, $u\big(c(t), c_N(t)\big)$, and inelastically supplying one unit of labor. Labor is supplied to the tradable sector, $\ell(t)$, and the non-tradable sector, $\ell_N(t) = 1 - \ell(t)$. Production in the non-tradable sector uses only labor with a constant returns technology, $y_N(t) = A_N(t)\ell_N(t)$, and the market for non-tradables is competitive. Assuming constant non-tradable productivity and normalizing $A_N(t) \equiv 1$, this economy is mathematically isomorphic to the one described in Section 2, with leisure replaced by non-tradable consumption, $c_N = y_N = 1-\ell$, and the wage rate equalling the price of non-tradables, $p_N(t) = w(t)$, maintaining the tradable good as numeraire. The equilibrium characterization in Lemma 2 still applies with $y(t)$ now denoting tradable output, or aggregate revenues of the tradable sector only.

Furthermore, the planner's problems studied in Section 4 also stays unchanged and Lemma 3 still applies, with an interpretational change that instead of labor supply subsidizes, $\varsigma_\ell(t)$, the planner is using a tax on non-tradable goods, $\tau_N(t)$, to manipulate the demand for non-tradables (which is the counterpart to the labor supply condition (27)):

$$\frac{u_N}{u_c} = (1 + \tau_N)p_N,$$

with the tax revenues rebated lump-sum back to the households.[36] An alternative implementation uses a labor tax in the tradable sector, which we also denote with τ_N. In this case, τ_N introduces a wedge between the wage rate and non-tradable price, $p_N = (1 + \tau_N)w$,

[36]For illustration purposes we assume that entrepreneurs do not consume non-tradables, but this assumption can be easily relaxed.

and the equilibrium allocation of labor to the two sectors is described by:

$$\frac{u_N}{u_c} = (1+\tau_N)w, \qquad w = (1-\alpha)\frac{y(x,\ell)}{\ell}, \tag{42}$$

where the second equation is labor demand in the tradable sector (see (19) in Lemma 2), and it holds under both implementations.

Since this environment is mathematically isomorphic to the one studies in Sections 2–4, the characterization of the optimal policy in Propositions 2–4 still applies, however, now it has implications for the real exchange rate, which in this model is pinned down by the (after-tax) price of non-tradables. When available transfers to the entrepreneurs in the tradable sector are bounded (or, for simplicity, unavailable, as we maintain in what follows), the planner optimally taxes the non-tradable sector—either consumption, or labor supply—in the early phases of transition (since optimal $\tau_N \equiv \varsigma_\ell$; recall Figure 2). Therefore, the planner makes non-tradables more expensive during the initial phase of transition, and the economy faces an *appreciated* real exchange rate. As we show below, this conclusion is not robust to the choice of the policy instrument.

5.1 Optimal intertemporal wedge

Now assume that the planner has no ability to differentially treat tradables and non-tradables—neither in consumption, nor in supply of production inputs—that is, the planner lacks the static tax instrument, τ_N, which affects the allocation of labor across sectors. For example, the planner may be bound by international trade agreement from using subsidies to the tradable sector, or simply not able to observe the division of labor input between tradable and non-tradable production. Note that subsidizing the overall labor supply is ineffective in this economy. However, even if we relax the assumption of inelastic labor supply, the planner specifically wants to direct labor to the tradable sector rather than increase the overall labor supply.

Assume further that the planner still has the ability to distort the allocation of overall consumption across time using either time-varying consumption taxes, or equivalently a savings subsidy, ς_b, which we already introduced in Section 4.1. The distortion to the consumption allocation can be effective in this economy, as it both reduces the demand for non-tradables consumption (and hence labor demand in the non-tradable sector) and increases labor supply through income effect. Both forces—lower demand for labor in the non-tradable sector and increased labor supply—reduce equilibrium wage and hence increase

entrepreneurial profits and speed up wealth accumulation. In the stylized framework of this section we consider inelastic labor supply, and hence only the former force (decreased non-tradable labor demand) is at play. However, if we reinterpret our model as a one-sector economy of Section 2, then it is only the latter force (income effect on labor supply) that is present.

Under these circumstances, the planner's problem is equivalent to (P1) in Section 4.2 with an additional constraint that labor supply across sectors cannot be directly manipulated, that is $\tau_N = 0$ in (42), which we can write as:

$$\frac{u_N}{u_c} = (1-\alpha)\frac{y}{\ell}. \tag{43}$$

In Appendix A.7 we characterize the solution to this extended planner's problem (P1) with added constraint (43).

We show, that without the ability to directly manipulate the labor supply across sectors, the planners chooses to distort the intertemporal consumption allocation according to:

$$u_c(t) = \bar{\mu}\big[1 + \Gamma(t)\big(\nu(t) - 1\big)\big],$$

where $\nu(t) > 0$ as before is the co-state associated with the entrepreneurial wealth (31) and $\Gamma(t) \geq 0$ measures the effectiveness of reduced consumption to increase the supply of labor to the tradable sector (see formal expression in Appendix A.7).[37] Therefore, the planner reduces consumption (increases the marginal utility) when $\nu(t)$ is high, that is when wealth $x(t)$ is low. This allows to increase tradable labor supply $\ell(t)$ without violating (43). When the savings subsidy, $\varsigma_b(t)$, is used as the policy instrument, this increase in tradable labor supply results in the reduction in wages and the price of non-tradables:

$$p_N(t) = w(t) = (1-\alpha)\frac{y\big(x(t), \ell(t)\big)}{\ell(t)}.$$

This, in turn, implies a *depreciated* real exchange rate, in contrast with the outcome when a static tax on non-tradables is used as a policy tool. This result is noteworthy, since the same policy objective of shifting labor towards the tradable sector has opposing implications for the real exchange rate movement depending on which policy instrument is used. Indeed, real exchange rate in this case is neither closely related to the policy instruments, nor constitutes

[37] Consider the special case of a Cobb-Douglas utility function over tradables and non-tradables. In this case, $\Gamma(t) = \gamma\phi\ell(t)/\big[\gamma\phi(1-\ell(t)) + \ell(t)\big] > 0$, where ϕ is the non-tradable share. Under the alternative interpretation of a one-sector economy with elastically supplied labor, $\Gamma(t) \equiv 0$ under GHH preferences, $u(c, 1-\ell) = U\big(c - v(\ell)\big)$; and $\Gamma(t) > 0$ whenever there is an income effect on labor supply.

a sufficient statistic for the policy objective. Therefore, in the context of our framework, there is no robust link between the real exchange rate and economic growth, although the policies which operate through the distortion of the intertemporal margin do simultaneously lead to an undervalued real exchange rate during the initial phase of accelerated convergence (*cf.* Rodrik 2008 and see also the comment by Woodford 2008).

Additionally, the savings subsidy, or alternatively forced savings, reduces the consumption of both tradables and non-tradables, and expands output of tradables, thereby leading to increased exports and growing net foreign asset position. At the same time, from Lemma 2, greater supply of labor to the tradable sector results in greater production capital inflow into the country (an increase in $\kappa(t)$). That is, the economy experience simultaneously a net capital outflow (current account surplus) and an inflow of foreign production capital (FDI or portfolio investments). In ongoing work, we are exploring in how far these conclusions go through in a more symmetric environment where the nontradable sector is also subject to financial frictions.

6 Discussion

The presence of financial frictions means that there may be a role for governments in developing countries to accelerate economic development by intervening in product and factor markets. In our framework, such financial frictions justify a policy intervention that reduces wages and increases labor supply in the short-run so as to speed up entrepreneurial wealth accumulation and to generate higher labor productivity and wages in the long-run.

To gain a better understanding of the optimal development policies and their implications for a country's growth dynamics, we set up our Ramsey problem in as simple an environment as possible. By making a number of strong assumptions, we obtain a sharp analytical characterization of the optimal policies and a precise qualitative understanding of the mechanisms at play, which are likely to persist in much more detailed and complex quantitative models with financial frictions.

We now provide a discussion of the assumptions made in the paper, as well as some of the extensions we provide in the appendix. We conduct our analysis in a small open economy with perfect international capital mobility, limited only by borrowing constraints of individual agents. Indeed, staying within their borrowing constraints, agents can freely borrow or lend capital at the international rate of return r^*, without facing any adjustment costs. As a result, the stock of capital is not a state variable in our analysis, and only the entrepreneurial

wealth is. In Appendix A.10, we describe an extension of our environment to the case of a closed economy with no international capital mobility, where we show that the planner's problem remains similar to problem (P1) of Section 4. In case when entrepreneurs cannot borrow capital outside their sector, the planner's problem stays isomorphic to (P1). Alternatively, when entrepreneurs can borrow capital from households, the problem generalizes to one in which the planner can actively manipulate the equilibrium interest rate, $r(t)$, in addition to the equilibrium wage rate. As a result, the planner in general chooses to distort the intertemporal consumption allocation in addition to distorting the static labor supply. One can also consider extensions with capital adjustment costs, but this comes at a loss of analytical tractability and needs to be done numerically. Nonetheless, we expect the same forces identified in our analysis to be present in this richer environment.

Another assumption we make in our baseline analysis is that the planner puts zero weight on the welfare of entrepreneurs. Appendix A.8 relaxes this assumption and extends the planner's problem (P1) to allow for a positive weight on the average expected value of all entrepreneurs. We show that our analysis stays qualitatively the same, with the planner choosing a uniformly greater labor supply subsidy. One difference is that in this case the planner may choose to subsidize labor supply even in the long run, but the pattern of declining labor supply subsidies over time still persists.

We make very stylized assumptions about the iid productivity process and the linearity of technology (i.e., constant returns to scale) of individual entrepreneurs. This allows us to maintain analytical tractability of the optimal policy analysis, in particular due to straightforward aggregation of our economy, which does not require the knowledge of the distribution of entrepreneurial wealth apart from its mean. Moll (2012) shows how to relax the iid assumption at some moderate cost to model's tractability. The model can be analyzed quantitatively without making either assumption, and we see this as an important next step to quantify the magnitudes and durations of optimal policies, yet we expect the qualitative insights obtained in our stylized environment to persist beyond this generalizations of the model.

We introduce financial frictions in a very stylized way, which however has become common in both qualitative and quantitative studies of the impact of financial frictions. The incentive compatibility constraint behind the borrowing friction is static, and hence leaves no role for dynamic incentive provision, as in the models of endogenously incomplete markets. Extending the environment to allow for a deeper intertemporal incentive compatibility constraint is an important future step to better understand the advantages and limitations

of various policy instruments in fostering economic development.[38] Nonetheless, we think that our borrowing constraint captures in a stylized way the essence of financial frictions in that the current assets of entrepreneurs limit the scale of their business operations and capacity to borrow. To the extent this is the case, we expect the mechanisms identified in our work to still be at play, and our qualitative insights to carry over to some degree to richer environments.

Our framework is also tractable enough to be extended in a number of different directions. For example, we can study the Ramsey-optimal policies in a multi-sector economy where each sector is characterized by financial frictions of differing severity and different initial conditions for the capitalization of entrepreneurs. Such an extension would open the door for the analysis of optimal sectoral policies to compare them with *industrial policies* used in practice. We took a first stab at a multi-sector environment in the simple extension in Section 5 with both tradable and non-tradable goods. However, the conclusions there were at least in part driven by the extreme asymmetry across sectors, for example, the assumption that only tradables are subject to financial frictions. A natural question is what the features of optimal policy are in a more symmetric environment where the tradable and non-tradable sectors are both subject to financial frictions. We are exploring some of these possibilities in ongoing work, but the exploration of many related questions is left for future research. Another natural application of our framework is to study the optimal policy response to cyclical fluctuations and transitory shocks.

[38] For example, the effects of labor supply and entrepreneur asset taxes on future incentive compatibility can differ by effecting differentially the outside option to entrepreneur from his possible deviation (e.g., if entrepreneur can hide his assets in the shadow and operate in the informal labor and product markets).

A Appendix

A.1 Frisch labor supply elasticity

For any utility function $u(c, 1-\ell)$ defined over consumption c and leisure $1-\ell$, consider the system of equations

$$u_c(c, 1-\ell) = \mu, \tag{A1}$$
$$u_\ell(c, 1-\ell) = \mu w. \tag{A2}$$

These two equations define ℓ and c as a function of the marginal utility μ and the wage rate w. The solution for ℓ is called the *Frisch labor supply* function and we denote it by $\ell = \ell^F(\mu, w)$. We have assumed that the utility function features a positive and finite Frisch labor supply elasticity for all (μ, w):

$$\varepsilon(\mu, w) \equiv \frac{\partial \log \ell^F(\mu, w)}{\partial \log w} = \frac{1}{-\frac{u_{\ell\ell}\ell}{u_\ell} + \frac{(u_{c\ell})^2 \ell}{u_{cc}}} \in (0, \infty), \tag{A3}$$

where the second equality comes from a full differential of (A1)–(A2) under constant μ, which we simplify using $w = u_\ell/u_c$ implied by (A1)–(A2). Therefore, the condition we impose on the utility function is:

$$-\frac{u_{\ell\ell}\ell}{u_\ell} > -\frac{(u_{c\ell})^2 \ell}{u_{cc}}, \tag{C2}$$

for all possible pairs $(c, 1-\ell)$. Due to convexity of $u(\cdot)$, this in particular implies $u_{\ell\ell} > 0$.

A.2 Value and policy functions of entrepreneurs

Lemma A1 *When the budget constraint of a log-utility entrepreneurs with discount rate δ can be written as $\mathrm{d}a = R_t(z)a - c_e$ for some $R_t(z)$, the consumption policy function is $c_e = \delta a$ and the expected value starting from initial assets a_0 is*

$$V_0(a_0) = \frac{1}{\delta}\log a_0 + \frac{1}{\delta}(r^* + \log\delta - 1) + \int_0^\infty e^{-\delta t}\left[\varsigma_x(t) + \frac{\alpha}{\eta}\frac{y\big(x(t), \ell(t)\big)}{x(t)}\right]\mathrm{d}t. \tag{A4}$$

Proof: This derivation follows the proof of Lemma 2 in Moll (2012). Denote by $V_t(a, z)$ the value to an entrepreneur with assets a and productivity z at time t, which can be expressed recursively as (see Ch.2 in Stokey, 2009):

$$\delta v_t(a, z) = \max_{c_e}\left\{\log c_e + \frac{1}{\mathrm{d}t}\mathbb{E}\{\mathrm{d}v_t(a, z)\}, \quad \text{s.t. } \mathrm{d}a = [R_t(z)a - c_e]\mathrm{d}t\right\},$$

where from (8), (9) and (11)

$$R_t(z) = r^*\left(1 + \lambda\big[z/\underline{z}(t) - 1\big]^+\right) + \varsigma_x(t),$$

where $\varsigma_x(t)$ is the asset subsidy introduced in Section 4, which for this calculation needs to be finite.

The proof proceeds with a guess and verify strategy. Guess that the value function takes the form $v_t(a, z) = B\tilde{v}_t(z) + B\log a$. Using this guess we have that $\mathbb{E}\{\mathrm{d}v_t(a, z)\} = B\mathrm{d}a/a + B\mathbb{E}\{\mathrm{d}\tilde{v}_t(z)\}$.

Rewrite the value function:

$$\delta B\tilde{v}_t(z) + \delta B \log a = \max_{c_e} \left\{ \log c_e + \frac{B}{a}\left[R_t(z)a - c_e\right] + B\frac{1}{dt}\mathbb{E}\{\mathrm{d}\tilde{v}_t(z)\} \right\}.$$

Take first order condition to obtain $c_e = a/B$. Substituting back in,

$$\delta B\tilde{v}_t(z) + \delta B \log a = \log a - \log B + BR_t(z) - 1 + B\frac{1}{dt}\mathbb{E}\{\mathrm{d}\tilde{v}_t(z)\}.$$

Collecting the terms involving $\log a$, we see that $B = 1/\delta$ so that $c_e = \delta a$ and $\dot{a} = [R_t(z) - \delta]a$, as claimed in (13) in the text. Finally, the value function is

$$v_t(a, z) = \frac{1}{\delta}\big(\tilde{v}_t(z) + \log a\big), \tag{A5}$$

confirming the initial conjecture, where $\tilde{v}_t(z)$ satisfies

$$\delta\tilde{v}_t(z) = \delta \log \delta - \delta + R_t(z) + \frac{1}{dt}\mathbb{E}\{\mathrm{d}\tilde{v}_t(z)\}. \tag{A6}$$

Next we calculate expected value:

$$V_0(a_0) = \int v_0(a_0, z)g_z(z)\mathrm{d}z = \frac{1}{\delta}\big(\tilde{V}_0 + \log a_0\big),$$

where $g_z(\cdot)$ is the pdf of z and $\tilde{V}_0 \equiv \int \tilde{v}_0(z)g_z(z)\mathrm{d}z$. Integrating (A6):

$$\delta\tilde{V}_t = \delta \log \delta - \delta + \int R_t(z)g(z)\mathrm{d}z + \dot{\tilde{V}}_t, \tag{A7}$$

where we have used that (under regularity conditions so that we can exchange the order of integration)

$$\int \frac{1}{dt}\mathbb{E}\{\mathrm{d}\tilde{v}_t(z)\}g_z(z)\mathrm{d}z = \frac{1}{dt}\mathbb{E}\left\{\mathrm{d}\int \tilde{v}_t(z)g_z(z)\mathrm{d}z\right\} = \frac{1}{dt}\mathbb{E}\{\mathrm{d}\tilde{V}_t\} = \dot{\tilde{V}}_t.$$

Integrating (A7) forward in time:

$$\tilde{V}_0 = \log \delta - 1 + \int_0^\infty e^{-\delta t}\int R_t(z)g_z(z)\mathrm{d}z\mathrm{d}t,$$

and hence

$$V_0(a_0) = \frac{1}{\delta}\log a_0 + \frac{1}{\delta}(\log \delta - 1) + \int_0^\infty e^{-\delta t}\left[\int R_t(z)g_z(z)\mathrm{d}z\right]\mathrm{d}t. \tag{A8}$$

Finally, under the Pareto distribution assumption for z, we calculate:

$$\begin{aligned}\int R_t(z)g_z(z)\mathrm{d}z &= r^* + \varsigma_x(t) + \lambda r^*\int_{\underline{z}(t)}^\infty \left(\frac{z}{\underline{z}(t)} - 1\right)\eta z^{-\eta-1}\mathrm{d}z \\ &= r^* + \varsigma_x(t) + \frac{\lambda r^*}{\eta - 1}\underline{z}(t)^{-\eta} = r^* + \varsigma_x(t) + \frac{\alpha}{\eta}\frac{y\big(x(t), \ell(t)\big)}{x(t)},\end{aligned}$$

where the last equality uses (18) to substitute in for $\underline{z}(t)^{-\eta}$. Substituting this expression into (A8) and taking the integral results in (A4). ■

A.3 Inefficiency of decentralized equilibrium

First, we provide an example of a transfer policy between workers and entrepreneurs which makes every single agent better off. [TO BE COMPLETED]

Proof of Proposition 1 Consider the following problem:

$$\begin{aligned}
&\max_{\{c,\ell,b,x\}_{t\geq 0}} \int_0^\infty e^{-\rho t} u(c, 1-\ell)\mathrm{d}t && \text{(P0)}\\
&\text{subject to} \qquad c + \dot{b} = (1-\alpha)y(x,\ell) + r^* b,\\
&\qquad\qquad\qquad\quad \dot{x} = \frac{\alpha}{\eta} y(x,\ell) + (r^* - \delta)x,\\
&\int_0^\infty e^{-\delta t}\frac{\alpha}{\eta}\frac{y\big(x,\ell\big)}{x}\mathrm{d}t \geq \int_0^\infty e^{-\delta t}\frac{\alpha}{\eta}\frac{y\big(\tilde{x},\tilde{\ell}\big)}{\tilde{x}}\mathrm{d}t,
\end{aligned}$$

where we denote by $\{\tilde{x}, \tilde{\ell}\}$ the path of entrepreneurial wealth and labor supply in the decentralized equilibrium without government intervention (defined in Section 2.4).

Note that, according to Lemma 3, the first two constraints in (P0) imply that the chosen allocation $\{c, \ell, b, x\}$ must be an equilibrium allocation supported by an aggregate labor supply subsidy to workers and an aggregate savings subsidy to workers, both financed by a lump-sum tax on workers, and without using a savings subsidy to entrepreneurs ($\varsigma_x \equiv 0$). From Lemma A1, the third constraint in (P0) ensures that the expected value to every entrepreneur, $V_0(a_0)$, is no less than under the decentralized allocation. Therefore, (P0) is a problem of choosing an equilibrium allocation supported by savings and labor supply subsidies to workers which maximizes workers' welfare subject to keeping every entrepreneur at least as well-off in expected terms as in the decentralized equilibrium. Note that the decentralized allocation, $\{\tilde{c}, \tilde{\ell}, \tilde{b}, \tilde{x}\}$, satisfies all three constraints and therefore is a feasible choice. If the solution to (P0) is different from $\{\tilde{c}, \tilde{\ell}, \tilde{b}, \tilde{x}\}$, then there exists a coordinated change in the workers' choice of $\{c, \ell\}$ which makes every agent in the economy better off.

Denote the co-states on the first two constraints by μ and $\mu\nu$, and the Lagrange multiplier on the third constraint by θ. The present-value Hamiltonian for this problem is

$$\mathcal{H} = u(c, 1-\ell) + \theta e^{-(\delta-\rho)t}\frac{\alpha}{\eta}\frac{y\big(x,\ell\big)}{x} + \mu\big[(1-\alpha)y(x,\ell) + r^* b - c\big] + \mu\nu\left[\frac{\alpha}{\eta}y(x,\ell) + (r^*-\delta)x\right]$$

with the optimality conditions with respect to b, c and ℓ are given by:

$$\begin{aligned}
\dot{\mu} - \rho\mu = -\frac{\partial \mathcal{H}}{\partial b} &= -\mu r^*,\\
0 = \frac{\partial \mathcal{H}}{\partial c} &= u_c - \mu,\\
0 = \frac{\partial \mathcal{H}}{\partial \ell} &= -u_\ell + \left[\theta e^{-(\delta-\rho)t}\frac{\gamma}{x} + \mu\big(1-\gamma+\gamma\nu\big)\right](1-\alpha)\frac{y}{\ell},
\end{aligned}$$

implying, under the parameter restriction (C1), $\rho = r^*$, that $\dot{\mu} = 0$ and $u_c(t) = \mu(t) \equiv \bar{\mu}$ for all t,

which in turn means that (3) holds and $\varsigma_b \equiv 0$, and:

$$\frac{u_\ell}{u_c} = \left[\frac{\theta}{\bar{\mu}} e^{-(\delta-\rho)t}\frac{\gamma}{x} + \big(1-\gamma+\gamma\nu\big)\right](1-\alpha)\frac{y}{\ell} \qquad \Rightarrow \qquad \varsigma_\ell = \frac{\theta}{\bar{\mu}} e^{-(\delta-\rho)t}\frac{\gamma}{x} + \gamma(\nu-1).$$

Informally, co-state ν is the shadow value of entrepreneurial wealth which decreases as x increases, and therefore for $\delta \geq \rho$, ς_ℓ is decreasing during transition when x starts below the steady state. This allocation is therefore different from the decentralized allocation which corresponds to $\varsigma_\ell = 0$, and therefore the decentralized allocation can be improved upon by a coordinated change in labor supply. Since a reduction in labor supply at each point in time will leave entrepreneurs worse off, to achieve a Pareto improvement the labor supply needs to be adjusted upwards at least in the early phase of transition.

[TO BE COMPLETED]

A.4 Optimality conditions for the planner's problem

Consider the more general problem (P2). The present-value Hamiltonian for this problem is given by:

$$\mathcal{H} = u(c,1-\ell)+\mu\big[(1-\alpha)y(x,\ell)+r^*b-c-\varsigma_x x\big]+\mu\nu\big[\tfrac{\alpha}{\eta}y(x,\ell)+(r^*+\varsigma_x-\delta)x\big]+\mu\bar{\xi}(S-\varsigma_x x)+\mu\underline{\xi}(\varsigma_x x-s),$$

where we have introduced two additional Lagrange multipliers $\mu\bar{\xi}$ and $\mu\underline{\xi}$ for the corresponding bounds on transfers. The full set of optimality conditions is given by:

$$0 = \frac{\partial\mathcal{H}}{\partial c} = u_c - \mu, \tag{A9}$$

$$0 = \frac{\partial\mathcal{H}}{\partial \ell} = -u_\ell + \mu\big(1-\gamma+\gamma\nu\big)(1-\alpha)\frac{y}{\ell}, \tag{A10}$$

$$0 = \frac{\partial\mathcal{H}}{\partial \varsigma_x} = \mu x\left(\nu - 1 - \bar{\xi} + \underline{\xi}\right), \tag{A11}$$

$$\dot{\mu} - \rho\mu = -\frac{\partial\mathcal{H}}{\partial b} = -\mu r^*, \tag{A12}$$

$$\dot{(\mu\nu)} - \rho\mu\nu = -\frac{\partial\mathcal{H}}{\partial x} = -\mu\big(1-\gamma+\gamma\nu\big)\frac{\alpha}{\eta}\frac{y}{x} - \mu\nu(r^*-\delta) - \mu\varsigma_x\left(\nu - 1 - \bar{\xi} + \underline{\xi}\right), \tag{A13}$$

where we have used the fact that $\partial y/\partial\ell = (1-\gamma)y/\ell$ and $\partial y/\partial x = \gamma y/x$ which follow from the definition of $y(\cdot)$ in (17), as well as the definition of γ. Additionally, we have two complementary slackness conditions for the bounds-on-transfers constraints:

$$\bar{\xi} \geq 0, \quad \varsigma_x x \leq S \qquad \text{and} \qquad \underline{\xi} > 0, \quad \varsigma_x x \geq s. \tag{A14}$$

Under parameter restriction (C1), $r^* = \rho$, (A12) and (A9) imply:

$$\dot{\mu} = 0 \qquad \Rightarrow \qquad u_c(t) = \mu(t) \equiv \bar{\mu} \quad \forall t.$$

With this, (A10) becomes (33) in the text. Given $\mu \equiv \bar{\mu}$ and $r^* = \rho$ and (A11), (A13) becomes (34) in the text. Finally, (A11) can be rewritten as:

$$\nu - 1 = \bar{\xi} - \underline{\xi}.$$

When both bounds are slack, (A14) implies $\bar{\xi} = \underline{\xi} = 0$, and therefore $\nu = 1$. When the upper bound is binding, $\nu - 1 = \bar{\xi} > 0$, and when the lower bound is binding $\nu - 1 = -\underline{\xi} < 0$. Therefore, we obtain the complementary slackness condition (40) in the text.

The case with no transfers ($S = -s = 0$) results in planner's problem (P1) with Hamiltonian provided in footnote 24. The optimality conditions in this case are (A9), (A10), (A12) and

$$(\dot{\mu\nu}) - \rho\mu\nu = -\frac{\partial \mathcal{H}}{\partial x} = -\mu\big(1 - \gamma + \gamma\nu\big)\frac{\alpha}{\eta}\frac{y}{x} - \mu\nu(r^* - \delta),$$

which also results in (34) after simplification.

The case with unbounded transfers ($S = -s = +\infty$) allows to simplify the problem considerably, as described in footnote 31. Indeed, in this case we defined a single state variable $m \equiv b + x$ and combine the two constraints in problem (P2), to write the resulting problem as:

$$\begin{aligned} \max_{\{c,\ell,x,m\}_{t\geq 0}} \quad & \int_0^\infty e^{-\rho t} u(c, 1-\ell)\mathrm{d}t \\ \text{subject to} \quad & \dot{m} = \big(1 - \alpha + \alpha/\eta\big)y(x,\ell) + r^* m - \delta x - c, \end{aligned} \tag{P3}$$

with a corresponding present-value Hamiltonian:

$$\mathcal{H} = u(c, 1-\ell) + \mu\big[\big(1 - \alpha + \alpha/\eta\big)y(x,\ell) + r^* m - \delta x - c\big],$$

with the optimality conditions given by (A9), (A12) and

$$0 = \frac{\partial \mathcal{H}}{\partial \ell} = -u_\ell + \mu(1-\alpha)\frac{y}{\ell}, \tag{A15}$$

$$0 = \frac{\partial \mathcal{H}}{\partial x} = \mu\left(-\delta + \frac{\alpha}{\eta}\frac{y}{x}\right). \tag{A16}$$

(A15) immediately implies $\varsigma_\ell \equiv 0$, and (A16) pins down x/ℓ at each instant. The required transfer is then backed out from the aggregate entrepreneurial wealth dynamics (29).

The case with bounded transfers Consider the case with $S < \infty$. There are two possibilities: (a) $s \leq -r^*\bar{x}$, as discussed in the text; and (b) $r^*\bar{x} < s \leq 0$, which we consider first. In this case there are two regions:

1. for $x < \bar{x}$, $\varsigma_x x = S$ binds, $\bar{\xi} = \nu - 1 > 0$ and $\underline{\xi} = 0$. This immediately implies $\varsigma_\ell = \gamma(\nu - 1) > 0$, and the dynamics of (x, ς_ℓ) is as in Proposition 2, with the difference that $\dot{x} = \alpha y/\eta + (r^* - \delta)x + S$ with $S > 0$ rather than $S = 0$.

2. when $x = \bar{x}$ is reached, the economy switches to the steady state regime with $\bar{\varsigma}_x \bar{x} = s < 0$ binding, and hence $\nu - 1 = -\underline{\xi} < 0$ and $\bar{\xi} = 0$, in which:

$$\begin{aligned} \frac{\alpha}{\eta}\frac{y\big(\bar{x}, \bar{\ell}\big)}{\bar{x}} &= (\delta - r^*) - \frac{s}{\bar{x}} < \delta, \\ \bar{\varsigma}_\ell = \gamma\big(\bar{\nu} - 1\big) &= \frac{-\gamma}{\gamma + (1-\gamma)\frac{\delta\bar{x}}{r^*\bar{x} + s}} < 0. \end{aligned}$$

When the second (steady state) regime is reached, there is a jump from labor supply subsidy to a labor supply tax, as well as a switch in the aggregate transfer to entrepreneurs from S to s.

In the alternative case when $s < -r^*\bar{x}$, the first region is the same, and in steady state $\bar{\varsigma}_x\bar{x} = -r^*\bar{x} > s$ and hence the constraint is not binding: $\underline{\xi} = \bar{\xi} = \bar{\nu} - 1 = \bar{\varsigma}_\ell = 0$. The steady state in this case is characterized by (A15)–(A16), and $\bar{\varsigma}_x = -r^*$ ensures $\dot{x} = 0$ at $\bar{x}$. In this case, ς_ℓ continuously declines to zero when steady state is reached, and the aggregate transfer to entrepreneurs jumps from S to $-r^*\bar{x}$.

A.5 Proof of Proposition 2

Consider (31), (36) and (37). Under parameter restriction (C1), $r^* = \rho$, and households' marginal utility is constant over time $\mu(t) = u_c(t) = \bar{\mu}$ for all t. Using the definition of the Frisch labor supply function (see Appendix A.1), (19) and (17), (36) can be written as

$$\ell = \ell^F\Big(\bar{\mu}, (1+\varsigma_\ell)(1-\alpha)\Theta(x/\ell)^\gamma\Big).$$

For given $(\bar{\mu}, \varsigma_\ell, x)$, this is a fixed point problem in ℓ, and given positive and finite Frisch elasticity (A3) (i.e., under the condition on utility function (C2)) one can show that it has a unique solution, which we denote by $\ell = \ell(x, \varsigma_\ell)$, where we suppress the dependence on $\bar{\mu}$ for notational simplicity. Note that

$$\frac{\partial \log \ell(x,\varsigma_\ell)}{\partial \log x} = \frac{\varepsilon\gamma}{1+\varepsilon\gamma} \in (0,1), \qquad \frac{\partial \log \ell(x,\varsigma_\ell)}{\partial \log(1+\varsigma_\ell)} = \frac{\varepsilon}{1+\varepsilon\gamma} \in (0, 1/\gamma) \tag{A17}$$

where the bounds follow from (A3). Substituting $\ell(x, \varsigma_\ell)$ into (37) and (31), we have a system of two autonomous ODEs in (ς_ℓ, x)

$$\begin{aligned}
\dot{\varsigma}_\ell &= \delta(\varsigma_\ell + \gamma) - \gamma\,(1+\varsigma_\ell)\,\frac{\alpha}{\eta}\Theta\left(\frac{\ell(x,\varsigma_\ell)}{x}\right)^{1-\gamma}, \\
\dot{x} &= \frac{\alpha}{\eta}\Theta x^\gamma \ell(x,\varsigma_\ell)^{1-\gamma} + (r^* - \delta)x.
\end{aligned}$$

We now show that the dynamics of this system in (ς_ℓ, x) can be described with the phase diagram in Figure 1.

Steady State We first show that there exists a unique positive steady state $(\bar{\varsigma}_\ell, \bar{x})$, i.e. a solution to

$$\gamma\,(1+\bar{\varsigma}_\ell)\,\frac{\alpha}{\eta}\Theta\left(\frac{\ell(\bar{x},\bar{\varsigma}_\ell)}{\bar{x}}\right)^{1-\gamma} = \delta(\bar{\varsigma}_\ell + \gamma), \tag{A18}$$

$$\frac{\alpha}{\eta}\Theta\left(\frac{\ell(\bar{x},\bar{\varsigma}_\ell)}{\bar{x}}\right)^{1-\gamma} = \delta - r^*. \tag{A19}$$

Substituting (A19) into (A18) and rearranging, we obtain the expression for $\bar{\varsigma}_\ell$ in (38). From (A19), $\bar{x}$ is then the solution to the fixed point problem

$$\bar{x} = \left(\frac{\alpha}{\eta}\frac{\Theta}{\delta - r^*}\right)^{\frac{1}{1-\gamma}} \ell(\bar{x}, \bar{\varsigma}_\ell) \equiv \Phi(\bar{x}) \tag{A20}$$

Depending on the properties of the Frisch labor supply function, there may be a trivial solution $\bar{x} = 0$. We instead focus on positive steady states. Define

$$\varepsilon_1 \equiv \min_w \varepsilon(\bar{\mu}, w) > 0, \quad \varepsilon_2 \equiv \max_w \varepsilon(\bar{\mu}, w) < \infty, \quad \theta_1 \equiv \frac{\varepsilon_1\gamma}{1+\varepsilon_1\gamma} > 0, \quad \theta_2 \equiv \frac{\varepsilon_2\gamma}{1+\varepsilon_2\gamma} < 1.$$

From (A17), there are constants k_1 and k_2 such that $k_1 x^{\theta_1} \leq \ell(x, \bar{\varsigma}_\ell) \leq k_2 x^{\theta_2}$. Therefore there are $x_1 > 0$ sufficiently small such that $\Phi(x_1) > x_1$, and x_2 sufficiently large such that $\Phi(x_2) < x_2$. Finally, taking logs on both sides of (A20), we have

$$\tilde{x} = \tilde{\Theta} + \tilde{\ell}(\tilde{x}), \quad \tilde{\ell}(\tilde{x}) \equiv \log \ell(\exp(\tilde{x}), \bar{\varsigma}_\ell), \quad \tilde{\Theta} \equiv \log\left(\frac{\alpha}{\eta}\frac{\Theta}{\delta - r^*}\right)^{\frac{1}{1-\gamma}} \tag{A21}$$

satisfying $\tilde{\Theta} + \tilde{\ell}(\tilde{x}_1) > \tilde{x}_1$ and $\tilde{\Theta} + \tilde{\ell}(\tilde{x}_2) < \tilde{x}_2$, where $\tilde{x}_j \equiv \log a_j$, for $j \in \{1, 2\}$. From (A17), we have $0 < \tilde{\ell}'(\tilde{x}) < 1$ for all $\tilde{x}$ and therefore (A21) has a unique fixed point $\tilde{x}_1 < \log \bar{x} < \tilde{x}_2$.

Transition dynamics (A19) implicitly defines a function $x = \phi(\varsigma_\ell)$, which is the $\dot{x} = 0$ locus. We have that

$$\frac{\partial \log \phi(\varsigma_\ell)}{\partial \log(1+\varsigma_\ell)} = \frac{\frac{\partial \log \ell}{\partial \log(1+\varsigma_\ell)}}{1 - \frac{\partial \log \ell}{\partial \log x}} = \varepsilon \in (0, \infty).$$

Therefore the $\dot{x} = 0$ locus is strictly upward-sloping in (x, ς_ℓ) space, as drawn in Figure 1. The $\dot{\varsigma}_\ell = 0$ locus may be non-monotonic, but we know that the two loci only intersect once (the steady state is unique). The state space can then be divided into four quadrants. It is easy to see that $\dot{\varsigma}_\ell > 0$ for all points to the north-east of the $\dot{\varsigma}_\ell = 0$ locus, and $\dot{x} > 0$ for all points to the north-west of the $\dot{x} = 0$ locus, as indicated by the arrows in Figure 1. It then follows that the system is saddle path stable. Assuming Inada conditions on the utility function and given output function $y(\cdot)$ defined in (17), the saddle path is the unique solution to the planner's problem (P1). ■

A.6 Additional tax instruments (proof of Proposition 5)

We first prove an equilibrium characterization result, analogous to Lemma 2:

Lemma A2 *When subsidies $(\varsigma_x, \varsigma_\pi, \varsigma_y, \varsigma_k, \varsigma_w)$ are used, the output function is given by:*

$$y = \left(\frac{1+\varsigma_y}{1-\varsigma_k}\right)^{\gamma(\eta-1)} \Theta x^\gamma \ell^{1-\gamma}, \tag{A22}$$

where Θ and γ are defined as in Lemma 2, and we have:

$$\begin{aligned}
\underline{z}^{\eta} &= \frac{1-\varsigma_k}{1+\varsigma_y}\frac{\eta\lambda}{\eta-1}\frac{r^*}{\alpha}\frac{x}{y}, \\
(1-\varsigma_w)w\ell &= (1-\alpha)(1+\varsigma_y)y, \\
(1-\varsigma_k)r^*\kappa &= \frac{\eta-1}{\eta}\alpha(1+\varsigma_y)y, \\
\Pi &= \frac{\alpha}{\eta}(1+\varsigma_y)y.
\end{aligned}$$

Proof: Consider the profit maximization problem (41) in this case. The solution to this problem is given by:

$$\begin{aligned}
k &= \lambda a \mathbf{1}_{\{z\geq\underline{z}\}}, \\
\ell &= \left((1-\alpha)\frac{(1+\varsigma^y)A}{(1-\varsigma^w)w}\right)^{1/\alpha} zk, \\
\pi &= \left[\frac{z}{\underline{z}}-1\right](1-\varsigma^k)r^*k,
\end{aligned}$$

where the cutoff is defined by the zero-profit condition:

$$\alpha\big[(1+\varsigma^y)A\big]^{1/\alpha}\left(\frac{1-\alpha}{(1-\varsigma^w)w}\right)^{\frac{1-\alpha}{\alpha}}\underline{z} = (1-\varsigma^k)r^*. \tag{A23}$$

Finally, labor demand in the sector is given by:

$$\ell = \left((1-\alpha)\frac{(1+\varsigma^y)A}{(1-\varsigma^w)w}\right)^{1/\alpha}\frac{\eta\lambda}{\eta-1}x\underline{z}^{1-\eta}, \tag{A24}$$

and aggregate output is given by:

$$y = \left((1-\alpha)\frac{(1+\varsigma^y)}{(1-\varsigma^w)w}\right)^{\frac{1-\alpha}{\alpha}}A^{1/\alpha}\frac{\eta\lambda}{\eta-1}x\underline{z}^{1-\eta}. \tag{A25}$$

Combining these three conditions, we solve for $\underline{z}$, w and y, which result in the first three equations of the lemma. Aggregate capital demand and profits in this case are still given by:

$$\kappa = \lambda x\underline{z}^{-\eta} \qquad \text{and} \qquad \Pi = \kappa/(\eta-1),$$

and combining these with the solution for $\underline{z}^{\eta}$ we obtain the last two equations of the lemma. ■

The immediate implication of this lemma is that asset and profit subsidies do not affect the equilibrium relationships directly, but do so only indirectly through their affect on aggregate entrepreneurial wealth.

With this characterization, and given that the subsidies are financed by a lump-sum tax on households, we can write the planners problem as

$$\max_{\{c,\ell,b,x,\varsigma_x,\varsigma_\pi,\varsigma_k,\varsigma_w,\varsigma_y\}}\int_0^{\infty} e^{-\rho t}u\big(c(t),1-\ell(t)\big)\mathrm{d}t \tag{P4}$$

subject to

$$c+\dot{b} \leq \left[(1-\alpha)-\frac{\varsigma_y}{1+\varsigma_y}-\frac{\varsigma_k}{1-\varsigma_k}\frac{\eta-1}{\eta}\alpha-\varsigma_\pi\frac{\alpha}{\eta}\right](1+\varsigma_y)y(x,\ell,\varsigma_y,\varsigma_k)+r^*b-\varsigma_x x,$$
$$\dot{x}=(1+\varsigma_\pi)\frac{\alpha}{\eta}(1+\varsigma_y)y(x,\ell,\varsigma_y,\varsigma_k)+(r^*+\varsigma_x-\delta)x,$$

where $y(x,\ell,\varsigma_y,\varsigma_k)$ is defined in (A22) and the negative terms in the square brackets correspond to lump-sum taxes levied to finance the respective subsidies. Note that ς_w drops out from the constraints, and it can be recovered from

$$\frac{u_c}{u_\ell}=(1+\varsigma_\ell)w=\frac{1+\varsigma_\ell}{1-\varsigma_w}\cdot(1+\varsigma_y)(1-\alpha)\frac{y}{\ell},$$

assuming $\varsigma_\ell=0$, otherwise there is implementational indeterminacy since ς_ℓ and ς_w are perfectly substitutable policy instruments as long as $\varsigma_w=\varsigma_\ell/(1+\varsigma_\ell)$, as claimed in Proposition 5.

When unbounded asset or profit subsidies are available, we can aggregate the two constraints in (P4) in the same way we did in Appendix A.4 in planner's problem (P3) by defining a single state variable $m\equiv b+x$. The corresponding Hamiltonian in this case is:

$$\mathcal{H}=u(c,1-\ell)+\mu\left[\left(1-\alpha+\frac{\alpha}{\eta}-\frac{\varsigma_y}{1+\varsigma_y}-\frac{\varsigma_k}{1-\varsigma_k}\frac{\eta-1}{\eta}\alpha\right)\frac{(1+\varsigma_y)^{1+\gamma(\eta-1)}}{(1-\varsigma_k)^{\gamma(\eta-1)}}\Theta x^\gamma\ell^{1-\gamma}+r^*m-\delta x-c\right],$$

where we have substituted (A22) for $y(x,\ell)$. The optimality with respect to $(\varsigma_y,\varsigma_k)$ evaluated at $\varsigma_y=\varsigma_k=0$ are, after simplification:

$$\left.\frac{\partial\mathcal{H}}{\partial\varsigma_y}\right|_{\varsigma_y=\varsigma_k=0}\propto-\frac{1}{1-\alpha+\alpha/\eta}+1+\gamma(\eta-1)=0,$$
$$\left.\frac{\partial\mathcal{H}}{\partial\varsigma_k}\right|_{\varsigma_y=\varsigma_k=0}\propto-\frac{\frac{\eta-1}{\eta}\alpha}{1-\alpha+\alpha/\eta}+\gamma(\eta-1)=0,$$

and combining $\partial\mathcal{H}/\partial c=0$ and $\partial\mathcal{H}/\partial\ell=0$, both evaluated at $\varsigma_y=\varsigma_k=0$, we have:

$$u_\ell/u_c=(1-\alpha)y/\ell.$$

Finally, optimality with respect to m implies as before $\dot{\mu}=0$ and $u_c(t)=\mu(t)\equiv\bar{\mu}$ for all t. This implies that whenever profit and/or asset subsidies are available and unbounded, other instruments are not used:

$$\varsigma_y=\varsigma_k=(\varsigma_\ell+\varsigma_w)=\varsigma_b=0.$$

Indeed, both ς_π and ς_y, appropriately chosen, act as transfers between workers and entrepreneurs, and do not affect any equilibrium choices directly, in particular do not affect $y(\cdot)$, as can be seen from (A22). This is the reason why these instruments are favored over other distortionary ways to affect the dynamics of entrepreneurial wealth.

Examining (41), we see that the following combination of taxes $\varsigma_y=-\varsigma_k=-\varsigma_w=\varsigma$ is equivalent to a profit subsidy $\varsigma_\pi=\varsigma$, and therefore whenever these three instruments are jointly available, they are used in this way to replicate a profit subsidy. This completes the proof of the statements in Proposition 5. ■

A.7 Optimal intertemporal wedge

The planner's problem in this case can be written as:

$$\max_{\{c,\ell,b,x\}_{t\geq 0}} \int_0^\infty e^{-\rho t} u(c, 1-\ell) \mathrm{d}t \tag{P6}$$

$$\begin{aligned} \text{subject to} \qquad c + \dot{b} &= (1-\alpha) y(x,\ell) + r^* b, \\ \dot{x} &= \frac{\alpha}{\eta} y(x,\ell) + (r^* - \delta) x, \\ \frac{u_c}{u_\ell} &= (1-\alpha)\frac{y(x,\ell)}{\ell}, \end{aligned}$$

where the last constraint implies that the planner cannot distort labor supply, and we denote by $\mu\psi$ the Lagrange multiplier on the this additional constraint. We can write the Hamiltonian for this problem as:

$$\mathcal{H} = u(c, 1-\ell) + \mu\big[(1-\alpha) y(x,\ell) + r^* b - c\big] + \mu\nu\big[\tfrac{\alpha}{\eta} y(x,\ell) + (r^* - \delta) x\big] + \mu\psi\big[(1-\alpha) y(x,\ell) - h(c,\ell)\big],$$

where $h(c,\ell) \equiv \ell u_\ell(c, 1-\ell)/u_c(c, 1-\ell)$. The optimality conditions are:

$$\begin{aligned} 0 = \frac{\partial \mathcal{H}}{\partial c} &= u_c - \mu\big(1 + \psi h_c\big), \\ 0 = \frac{\partial \mathcal{H}}{\partial \ell} &= -u_\ell + \mu\big(1 - \gamma + \gamma\nu\big)(1-\alpha)\frac{y}{\ell} + \mu\psi\left((1-\gamma)(1-\alpha)\frac{y}{\ell} - h_\ell\right), \\ \dot{\mu} - \rho\mu = -\frac{\partial \mathcal{H}}{\partial b} &= -\mu r^*, \\ (\dot{\mu\nu}) - \rho\mu\nu = -\frac{\partial \mathcal{H}}{\partial x} &= -\mu\big(1 - \gamma + \gamma\nu\big)\frac{\alpha}{\eta}\frac{y}{x} - \mu\nu(r^* - \delta) - \mu\psi(1-\gamma)\frac{\alpha}{\eta}\frac{y}{x}. \end{aligned}$$

Under parameter restriction (C1), $r^* = \rho$, and the third condition implies $\dot{\mu} = 0$ and $\mu(t) \equiv \bar{\mu}$ for all t, however, now $u_c = \bar{\mu}(1 + \psi h_c)$ and is no longer constant in general, reflecting the use of the savings subsidy to workers. Combining this with the second optimality condition and the third constraint on the planner's problem, we have:

$$(1-\alpha)\frac{y}{\ell} = \frac{u_c}{u_\ell} = \frac{\big((1-\gamma)(1+\psi) + \gamma\nu\big)(1-\alpha)y/\ell - \psi h_\ell}{1 + \psi h_c},$$

which we simplify using $h = (1-\alpha)y$:

$$\psi = \frac{\gamma(\nu - 1)}{h_c + \ell h_\ell / h - (1-\gamma)}. \tag{A26}$$

Finally, the dynamics of ν satisfies:

$$\dot{\nu} = \delta\nu - \big((1-\gamma)(1+\psi) + \gamma\nu\big)\frac{\alpha}{\eta}\frac{y}{x},$$

and the distortion to the consumption smoothing satisfies:

$$u_c = \bar{\mu}(1 + \psi h_c) = \bar{\mu}(1 + \Gamma(\nu - 1)), \qquad \Gamma \equiv \frac{\gamma h_c}{h_c + \ell h_\ell / h - (1-\gamma)}. \tag{A27}$$

Recall that under (C1), $\dot{u}_c/u_c = -\varsigma_b$, and therefore $\varsigma_b > 0$ whenever ψh_c is decreasing.

A.8 Pareto weight on entrepreneurs

Consider an extension to the planning problem (P1) in Section 4.2 (without transfers, $\varsigma_x \equiv 0$) in which the planner puts a positive Pareto weight $\theta > 0$ on the utilitarian welfare criterion of all entrepreneurs:

$$\mathbb{V}_0 \equiv \int V_0(a)\mathrm{d}G_0(a) = \frac{1}{\delta}\int \log a \,\mathrm{d}G_0(a) + \frac{1}{\delta}(r^* + \log\delta - 1) + \int_0^\infty e^{-\delta t}\frac{\alpha}{\eta}\frac{y\big(x,\ell\big)}{x}\mathrm{d}t,$$

where $V_0(\cdot)$ is the expected value to an entrepreneur with initial assets a_0 given in (A4) (in Appendix A.2), and after we imposed $\varsigma_x \equiv 0$.

Since given the instruments the planner cannot affect the first two terms in $\mathbb{V}_0$, the planner's problem in this case can be written as:

$$\begin{aligned} \max_{\{c,\ell,b,x\}_{t\geq 0}} \quad & \int_0^\infty e^{-\rho t}u(c,1-\ell)\mathrm{d}t + \int_0^\infty \theta_t e^{-\delta t}\frac{\alpha}{\eta}\frac{y\big(x,\ell\big)}{x}\mathrm{d}t \qquad \text{(P7)} \\ \text{subject to} \quad & c + \dot{b} = (1-\alpha)y(x,\ell) + r^* b, \\ & \dot{x} = \frac{\alpha}{\eta}y(x,\ell) + (r^*-\delta)x, \end{aligned}$$

where we have generalized the weight on entrepreneur's to be a time-varying sequence $\{\theta_t\}$. The Hamiltonian for this problem is:

$$\mathcal{H} = u(c,1-\ell) + \theta_t e^{-(\delta-\rho)t}\frac{\alpha}{\eta}\frac{y}{x} + \mu\big[(1-\alpha)y(x,\ell) + r^* b - c\big] + \mu\nu\left[\frac{\alpha}{\eta}y(x,\ell) + (r^*-\delta)x\right].$$

The optimality conditions are $u_c(t) = \mu(t) = \bar{\mu}$ for all t and

$$\begin{aligned} \frac{\partial\mathcal{H}}{\partial\ell} &= -u_\ell + \bar{\mu}\left[\frac{\theta_t}{\bar{\mu}}e^{-(\delta-\rho)t}\frac{\gamma}{x} + (1-\gamma) + \gamma\nu\right](1-\alpha)\frac{y}{\ell} = 0, \\ \dot{\nu} - \rho\nu = -\frac{1}{\bar{\mu}}\frac{\partial\mathcal{H}}{\partial x} &= (\delta - r^*)\nu - \left[\frac{\theta_t}{\bar{\mu}}e^{-(\delta-\rho)t}\frac{\gamma}{x} + (1-\gamma) + \gamma\nu\right]\frac{\alpha}{\eta}\frac{y}{x}. \end{aligned}$$

The dynamic system characterizing (x,ν) is the same as in Section 4.2 with the exception of an additional term $\frac{\theta_t}{\bar{\mu}}e^{-(\delta-\rho)t}\frac{\gamma}{x} > 0$ in the condition above. When $\theta_t \equiv \theta$ is constant over time, this term asymptotically converges to zero under the parameter restriction (C1) that $\delta > \rho$, and therefore the steady state of this system is identical to that described in Proposition 2. Along the transition path, for any given value of ν (i.e., shadow value of x), however, the labor supply subsidy is strictly greater than that in Section 4.2:

$$\varsigma_\ell(t) = \gamma\big(\nu(t) - 1\big) + \frac{\theta_t}{\bar{\mu}}e^{-(\delta-\rho)t}\frac{\gamma}{x(t)}.$$

If we choose increasing Pareto weight on entrepreneurs to offset the difference in the discount factors (which is only a technical assumption) so that $\theta_t e^{-(\delta-\rho)t} \equiv \bar{\theta}$ for all t, we can have a positive labor

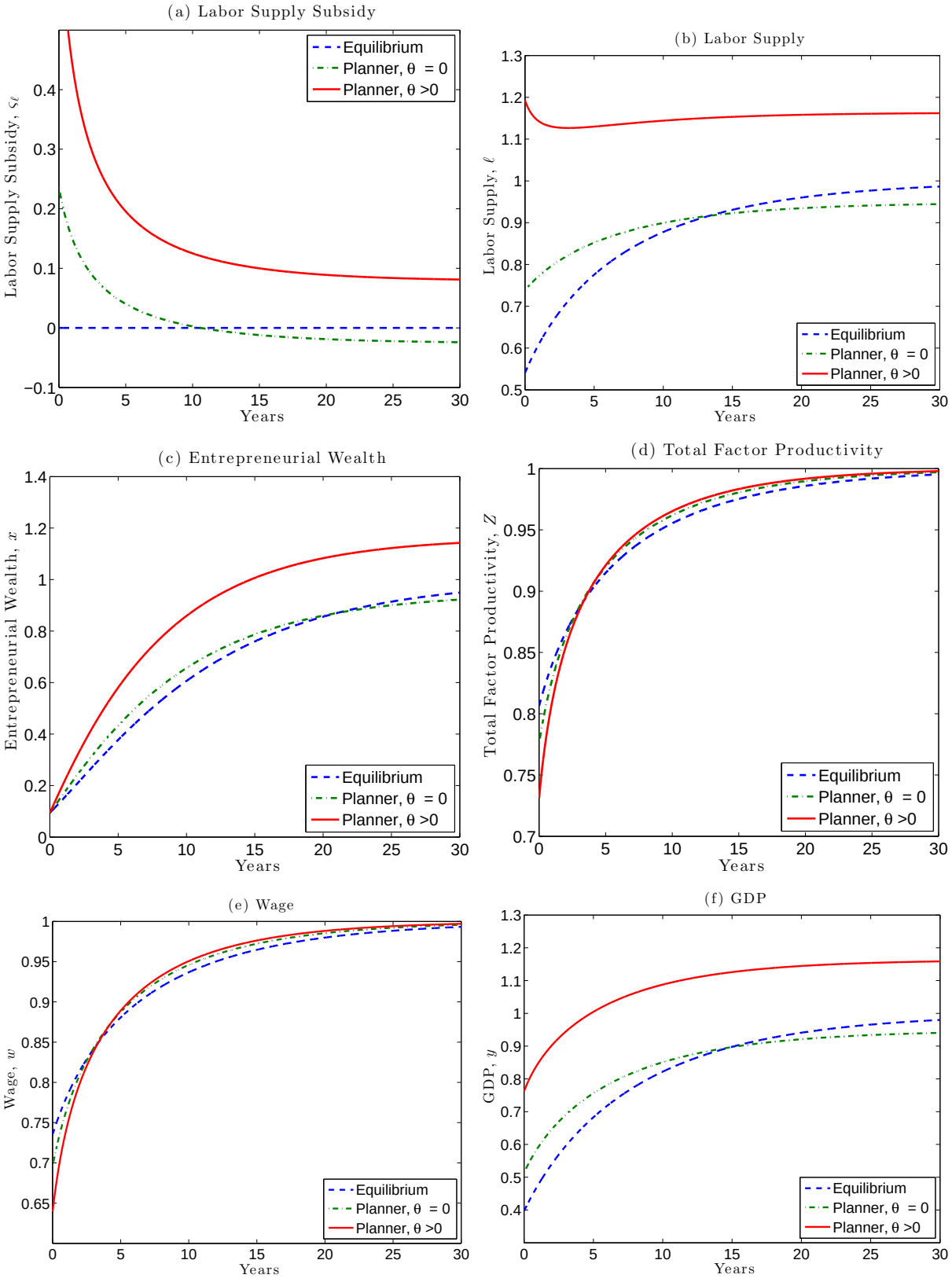


Figure A1: Planner's allocation with positive Pareto weight on entrepreneurs

supply subsidy even in the steady state:

$$\bar{\varsigma}_\ell = \gamma(\nu - 1) + \frac{\bar{\theta}}{\bar{\mu}}\frac{\gamma}{\bar{x}} = \frac{\frac{\bar{\theta}}{\bar{\mu}}\frac{\gamma}{\bar{x}} - \gamma\frac{r^*}{\delta}}{1 - \gamma + \gamma\frac{r^*}{\delta}},$$

which is positive for sufficiently large $\bar{\theta}$, as we show in the illustration of Figure A1, which plots the dynamic allocation in this case comparing it with the case of $\bar{\theta} = 0$ and the decentralized allocation.

A.9 Constrained efficient allocation

[TO BE COMPLETED]

A.10 Closed economy

[TO BE COMPLETED]

A.11 Model with wage bargaining

[TO BE COMPLETED]

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