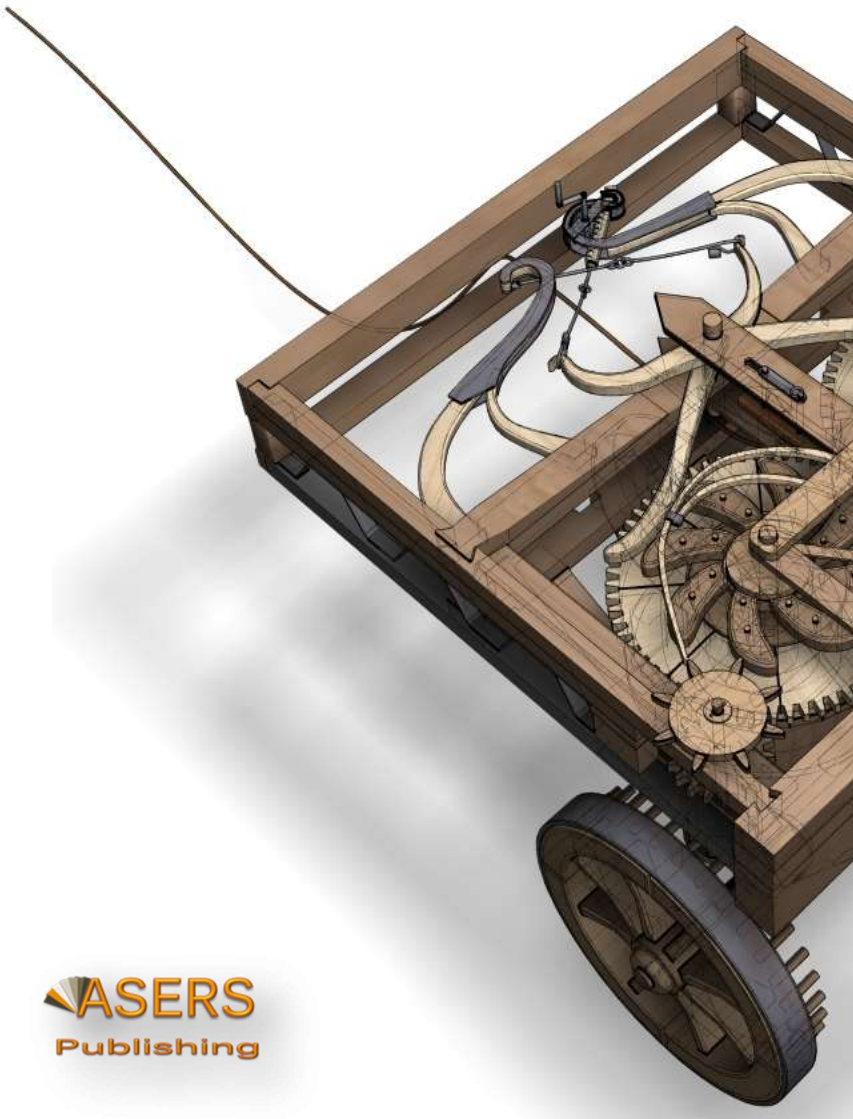
Theoretical and Practical Research in Economic Fields



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THE EFFECT OF REGULATIONS IN AN ENDOGENOUS GROWTH MODEL WITH RESEARCH AND DEVELOPMENT

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Abstract:

We utilize a relatively standard endogenous growth model with intermediaries and research and development (R&D). We augment the setup with government regulations to study the effect of regulations on aggregate allocations. The novelty is that we endogenize the problem of the regulator, so the number of regulations is determined within the model. Next, we solve the model and derive some comparative static results. The qualitative results confirm that more regulation leads to a lower number of intermediaries, but each of those is now larger. Investment in physical capital is higher, but that comes at the expense of lower investment in R&D, lower consumption, lower output, and lower welfare. Overall, the intuition that regulation is bad for the economy is confirmed.

***Keywords*:** endogenous growth model; regulation; intermediate goods; welfare.

JEL Classification: E60; L50.

Introduction

In this paper we start with a relatively standard endogenous growth model, as in Vasilev (2017), where growth is driven by research and development. More specifically, successful inventions lead to the production of new intermediate goods, which are then immediately incorporated as essential inputs into the production of final output. The novelty in this paper is the inclusion of government sector, which is in charge of issuing and implementing different regulations, which ultimately affect investment and innovation. Focusing on the social planner model, and assuming that government spending is financed through lump-sum taxes, we derive some important comparative static results. In particular, we show that more regulations positively affect investment in capital, but that happens at the cost of decreasing investment in R&D. The decrease in the number of intermediate goods negatively affects aggregate output and leads to lower consumption. Since consumption is the variable that households are maximizing over time, increase in regulatory activity decreases welfare. Overall, the simple model confirms the basic intuition that more regulation has an adverse effect for aggregate economic activity.

1. Model Setup

The model setup consists of preferences, technology and resources, which are described in turn.

Preferences: There is a representative household, which is infinitely lived and maximizes the stream of discounted utility

$$\sum_{t=0}^{\infty} \beta^t \ln(c_t), \quad 1.1$$

where $0 < \beta < 1$ is the discount factor, and c_t denotes consumption in period *t*.

Technology: the production technology is as follows: Final output, y_t, is produced by combining labor,h_t, and specialized inputs, z_{it}, which will be produced by intermediaries, or:

$$y_t = \int_0^{N_t} z_{it}^{\alpha} h_t^{1-\alpha} di, \quad 1.2$$

where N_t denotes the measure of intermediaries.

Next, each intermediate good *i* is produced using physical capital k_{it} as follows:

$$z_{it} = k_{it} - \bar{k_t}, \quad 1.3$$

where $\bar{k_t}$ is a time-varying regulatory cost. An alternative interpretation is one of "dead capital," or that some resources cannot be fully utilized. In order to produce positive output, each intermediary needs to invest in physical capital stock that exceeds the regulatory cost, expressed in terms of capital.

Aggregate physical capital in period *t* is then expressed as

$$k_t = \int_0^{N_t} k_{it}\, di. \quad 1.4$$

The law of motion for aggregate physical capital is

$$k_{t+1} = i_t^k + (1-\delta)k_t, \quad 1.5$$

where i_t^k denotes investment in physical capital, and $0 < \delta < 1$ is the depreciation rate.

Next, the mass of intermediate firms evolves according to the following law of motion:

$$N_{t+1} = N_t + i_t^N,$$

where i_t^N denotes investment in R&D ("ideas"). It takes resources to develop a profitable project, but once implemented, that knowledge is always available.

Finally, the resource constraint is as follows:

$$y_t = c_t + i_t^k + i_t^N + g_t, \quad 1.6$$

where g_t is the government production of regulation, which is going to be financed through the imposition of lump-sum taxes, τ_t. To abstract from debt, the government will be assumed to run a balanced budget in each time period

Resources: The economy starts with $k_0 > 0$ units of physical capital, and $N_0 > 0$ intermediate goods. Time endowment in each period is normalized to unity. (Given that the consumer does not value leisure, all time will be spent working in equilibrium.)

Regulator problem: The government ("the regulator") chooses $\bar{k_t}$ in each period to maximize

$$g_t - \tau_t^2 = (\bar{k_t})^{\theta} - \tau_t^2, \quad 1.7$$

subject to the budget constraint

$$r_t \bar{k_t} = \tau_t, \quad 1.8$$

where r_t denotes the real interest rate, parameter $0 < \theta < 1$ captures some decreasing returns in the "production function of regulations," while the quadratic form for taxes aims to capture the fact that varying taxes over time is costly. Next, plugging the budget constraint into the objective function, and maximizing with respect to the choice variable yields

$$\bar{k_t} = \bar{k} = [2/\theta]^{2-\theta}, \quad 1.9$$

where without any loss of generality we have normalized the real interest rate to unity. The interesting result is that the amount of regulation will be constant over time.

A Social planner will then maximize 1.1 subject to 1.2 – 1.6 and the initial conditions. Given that all intermediaries use the same production function, this will imply that capital will be allocated evenly (symmetrically) across intermediaries, *i.e.*

$$y_t = \int_0^{N_t} (k_{it} - \bar{k})^{\alpha} h_t^{1-\alpha} di = h_t^{1-\alpha} \int_0^{N_t} (\frac{k_t}{N_t} - \bar{k})^{\alpha} di = \int_0^{N_t} (\frac{k_t}{N_t} - \bar{k})^{\alpha} di = N_t^{1-\alpha} (k_t - N_t \bar{k})^{\alpha} \quad 1.10$$

In equilibrium, the optimality conditions produce a balanced growth path (BGP), or:

$$\frac{1}{\beta}(1+g) = \alpha\left(k_t - N_t\bar{k}\right)^{\alpha-1} N_t^{1-\alpha} + (1-\delta), \quad 1.11$$

and

$$\frac{1}{\beta}(1+g) = (1-\alpha)\left(k_t - N_t\bar{k}\right)^{\alpha} N_t^{-\alpha} + 1, \quad 1.12$$

where g denotes the growth rate in the economy. Equalizing the left-hand sides of 1.11 and 1.12, it can be easily established that there is only one pair of initial conditions that makes those two equations hold.

Next, totally differentiating one of the two equations describing the BGP, *e.g.* 1.11, and applying the Implicit Function theorem, we can derive that

$$\frac{dk_t}{d\bar{k}} > 0, \quad 1.13$$

or, in other words, aggregate capital increases with regulations. However, at the same time

$$\frac{dN_t}{d\bar{k}} < 0, \quad 1.14$$

i.e., more regulations lead to less intermediate goods, or less variety ("variety effect"). Each surviving intermediary will have more capital, and thus will be larger than before ("size effect"), in order to overcome the "dead capital effect"/regulatory cost and produce positive output. Combined, the two effects produce a lower growth rate in the economy (growth effect"). Indeed, a simple application of the envelope theorem produces

$$\frac{dy_t}{d\bar{k}} < 0, \quad 1.15$$

which means that more regulation has an adverse effect on aggregate final output, and that effect works through the negative effect on the number of intermediaries. In this setup, aggregate output positively depends on innovation, as each new intermediate good is immediately absorbed as an input into the production of the final good. Similarly, we can show that

$$\frac{di_t^N}{d\bar{k}} < 0, \quad 1.16$$

or that regulation supresses innovation, while it increases physical investment

$$\frac{di_t^k}{d\bar{k}} > 0, \quad 1.17$$

as the planner substitutes investment in ideas for investment in physical capital. It is also straightforward that

$$\frac{dg_t}{d\bar{k}} > 0, \quad 1.18$$

as more regulation requires more funding through lump-sum taxes to finance government spending. From the resource constraint it then follows (straightforward to show) that

$$\frac{dc_t}{d\bar{k}} < 0, \quad 1.19$$

or that consumption is lower with regulation, despite the increase in physical investment. In an economy driven by innovation, more regulation is bad for both final production and final consumption, and thus is bad for aggregate welfare. Testing these effects using data is straightforward and could be done along the lines of Stankov and Vasilev (2019). This empirical part is left outside the scope of the paper.

Conclusion

In this paper we extend an endogenous growth model, where growth is driven by investment in R&D, with government regulations. More specifically, successful inventions lead to the production of new intermediate goods, which are then immediately incorporated as essential inputs into the production of final output. We show that more regulations positively affect investment in capital, but that is at the cost of decreasing investment in R&D. In turn, the decrease in the number of intermediate goods negatively affects aggregate output, and leads to lower consumption and welfare. Overall, the setup confirms the intuition that more regulation has an adverse effect for aggregate economic activity.

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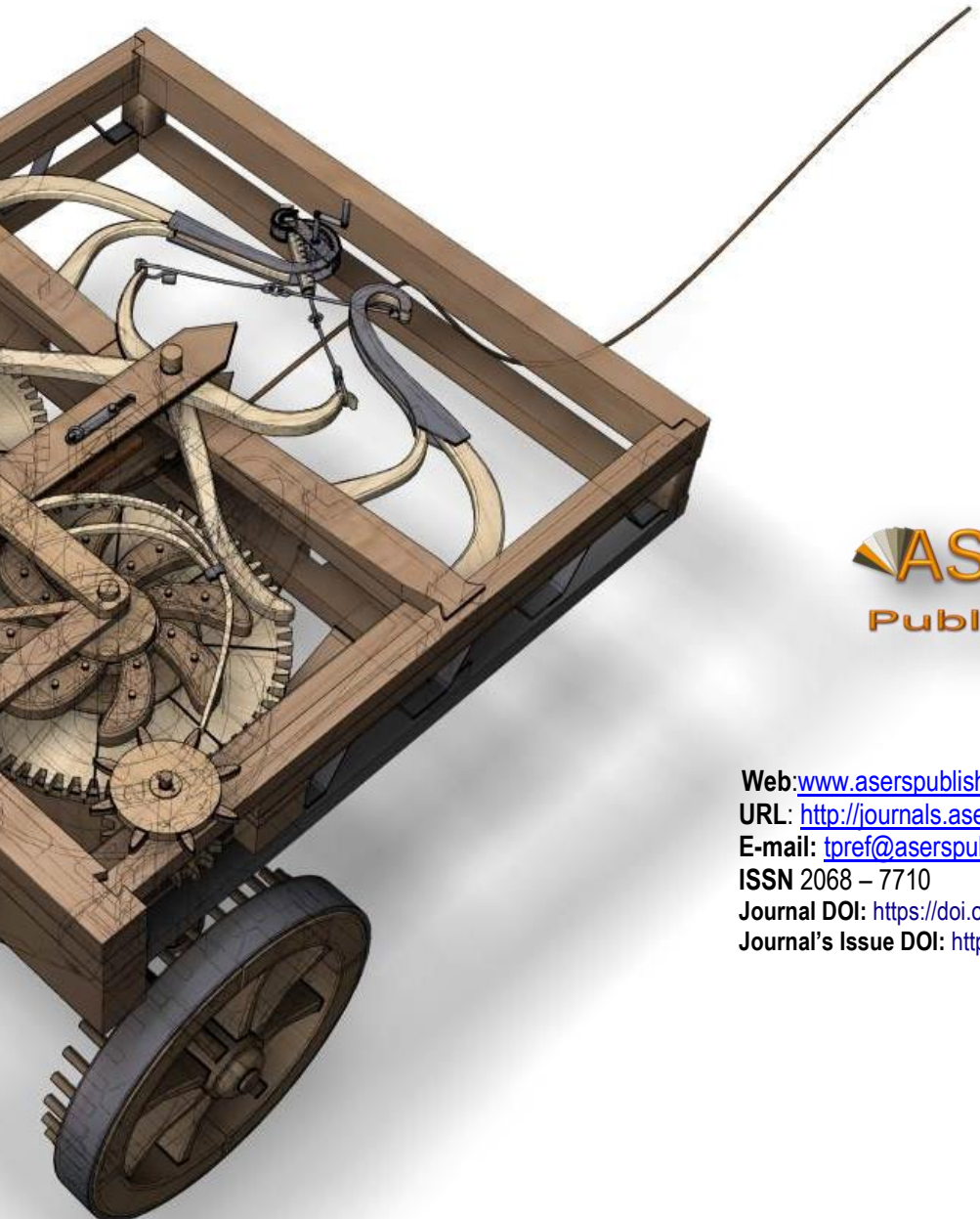

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