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Aggregate Demand, Economic Growth, and Unemployment

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Abstract

This paper argues that in a growing economy unemployment can be the cause of goods markets failures, even if these are purely transitory. As the economy grows, new firms wish to enter product markets. It may take some time, however, until their products are accepted on the market, which we model as a purely transitory demand shock. Firms who fail early entry will renege on the job offers, causing unemployment. Workers, anticipating this, will ask for a risk premium in insecure contracts, distorting price and supply decisions of firms, reducing incentives to invest into novel products, which reduces, but does not eliminate the number precarious job offers. Thus a transitory demand shock will lead to a persistent level of unemployment in a growing economy.

Keywords: transitory aggregate demand shocks, goods market unemployment, innovation, economic growth.

JEL-Classification: E24, O41.

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1 Motivation

Reading Okun's seminal contribution on the relationship between growth and unemployment carefully (Okun, 1970), we learn that according to his estimates, a one percent decline in the unemployment rate will lead to a three percent growth of output, whereas the recent political debate has inverted the relationship to argue that an increase in economic growth will reduce unemployment (European Commission, 1993).

The difference between these two position lies in the focus of the analysis. A modern version of Okun's law argues that whenever producers wish to extend output beyond productivity growth, they will need to hire workers, thus reducing unemployment, which is essentially a supply side argument. By contrast, Okun originally stressed the importance of demand factors in his analysis. He argues that as positive shock hits aggregate demand, firms begin to employ new workers, who contribute to additional aggregate demand, thus supporting a new equilibrium where unemployment has declined whilst output has grown.

However, the argument inverts for a negative shock to aggregate demand. Thus, if we assume that demand shocks are transitory and mean reverting, Okun's law cannot explain persistent unemployment, unless one assumes that labor markets fail to clear even in the long run.

Despite an interpretation quite different to the original Okun article, the renewed interest in the subject has led to a series of interesting empirical results. Starting with Bishop and Haveman (1979), Holloway (1989) and Courtney (1991), and more recently Candelon and Hecq (1998), a number of authors have suggested the breakdown of Okun's Law. However, in recent years cointegration studies have found renewed confidence in a relationship between unemployment and economic growth (Violante, 1999, Attfield and Silverstone, 1998)

Hence, whilst we have seen a breakdown of the relation between growth and unemployment in the short run, we find evidence that there is a relation in the long run. We can only explain this fact if we can identify different shocks in the economy, where some will cause a unidirectional shift in unemployment and economic growth, whereas others must have an opposite effect on growth and unemployment. Then, evidence collected in the short run can be distorted enough to eliminate the Okun relationship, whereas in the long-run, when the shocks fade out, the underlying structural relationship between unemployment and economic growth comes out.

Traditional models of economic growth and unemployment are not able to capture this fact. Consider first the Solow model (Solow, 1956). Assume that there is an exogenously given amount of unemployment. In the steady state, the optimal capital stock and GDP per worker will be independent of the level of unemployment. Then, a shock to unemployment will not affect these equilibrium values. However, as an increase in unemployment reduces the labor force, GDP and GDP per capita will decline, however still not affecting the growth rate of GDP. Therefore, only a permanent decline or increase in the unemployment rate, which is ruled out by definition, may give rise to the above mentioned structural relationship between growth and unemployment.

The endogenous growth literature, by contrast, can motivate a structural relation between growth and unemployment (Aghion and Howitt, 1993). However, we find that the relation between unemployment and growth suggested in this literature is unidirectional, and an increase in unemployment fosters economic growth (de Groot, 2000, p. 25). Therefore, any shock to unemployment should a exhibit a qualitatively equal effect on the economic growth rate, hence there is no reason why the structural relationship between unemployment and economic growth should not hold even in the short run. This is refuted by the evidence however.

We argue that demand considerations can account for both the breakdown of Okun’s law in the short run and the stability of Okun’s law in the long-run. As positive demand shocks foster economic growth and reduce unemployment, whereas supply shocks increase both economic growth and unemployment, we should find little correlation. As demand shocks fade out in the long run, however, we should be able to identify a long run relationship, which is supported by the evidence.

The paper proceeds as follows. The next chapter presents the demand side of the model. After a discussion on the product variety index in Dixit-Stiglitz utility functions, we argue that impediments to market entry can, apart from availability, determine the number of products on consumer markets. We argue that emerging firms face a transitory risk of failure to enter the product market. We then argue in chapter three that smallest of all possible labor market restrictions, the instantaneous inability to renegotiate labor contracts, can motivate permanent unemployment in this case, as opposed to the persistent rigidities required in the original Okun model. Moreover, as workers demand a risk premium to ensure themselves against unemployment, the optimal decision rules of firms are distorted, leading to lower entry and hence lower economic growth. Chapter four describes technological determinants of market entry. We propose a model of innovation networks to describe the permanent influx of new innovations on product markets. After giving failures to aggregate demand an externality interpretation in chapter five, we show in chapter six that distorted incentives for both workers and firms lead to unemployment whenever economic growth is positive. Chapter seven then derives the maximum feasible growth rate due to resource constraints, and chapter eight finally interprets the equilibrium of the economy.

2 Households

Households are assumed to provide one unit of labor inelastically, and to face an intertemporal trade-off between consumption and savings on the one hand, and an intratemporal tradeoff between differentiated consumption products on the other hand. Given homthetic preferences, we can solve the household problems in two stages. The intertemporal tradeoff is modeled according to the conventional logarithmic utility function,

$$U_s = \int_s^{\infty} e^{-\rho(t-s)} \ln c_t dt \qquad (1)$$

where ρ is the individual rate of time preference, and c_t is aggregate consumption over time *t*. Households maximize utility subject to an intertemporal budget constraint,

$$\dot{a}_t = r_t a_t + w_t(1-u_t) - c_t, \qquad (2)$$

which states that a household saves that part of interest income $r_t a_t$, and labor income w_t for those who expect not to be unemployed u_t, that is not spent on consumption c_t. Unemployed workers are assumed to receive no benefits. Hamiltonian optimization of the utility function subject to the budget constraint with respect to consumption, asset accumulation, and a shadow price of income yields the well-known Keynes-Ramsey-rule,

$$\hat{c}_t = r_t - \rho, \qquad (3)$$

where the hat (^) denotes the growth rate of consumption. This intertemporal Euler condition states that households will delay consumption into the future when the interest rate exceeds their individual rate of time preference. In each point of time, households demand differentiated services from an infinite variety according to the following constant elasticities of substitution subutility function,

$$c_t = [\int_0^{\infty} x_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di]^{\frac{\varepsilon}{\varepsilon-1}}, \qquad (4)$$

where $x_{i,t}$ is a specific service variety, ranging form zero to infinity. If households have chosen to purchase a total of c_t consumption goods at time t for a price p_t, then spending on all products will be constrained by

$$\int_0^{\infty} p_{i,t} x_{i,t} di \le p_t c_t, \qquad (5)$$

where $p_{i,t}$ is the price of a specific service *i*. The intratemporal household problem yields after optimization a demand function for a specific service,

$$x_{i,t} = (p_{i,t} / p_t)^{-\varepsilon} c_t, \qquad (6)$$

and we find that ε is the demand elasticity for any particular service. Moreover, we obtain a definition for the price index of services,

$$p_t = [\int_0^{\infty} p_{i,t}^{1-\varepsilon} di]^{\frac{1}{1-\varepsilon}}. \qquad (7)$$

Evidently, not all products will be available all the time. It is conventional to assume that unavailable products have an infinite price[1]. We have found it convenient to spilt the integral into two parts, where the available products at time t are in the interval $[0, m_t]$, whilst unavailable products range from $(m_t, \propto]$.[2] This leads to several simplifications. First note that despite the fact that some prices are infinitely high, the price index (7) is not, as

$$\lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} p_t = \lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} [\int_0^{m_t} p_{i,t}^{1-\varepsilon} di + \int_{m_t}^{\infty} p_{i,t}^{1-\varepsilon} di]^{\frac{1}{1-\varepsilon}} = [\int_0^{m_t} p_{i,t}^{1-\varepsilon} di]^{\frac{1}{1-\varepsilon}},$$

(7')

which implies that we only need to know prices of available products to measure the price index. As the prices of all available products are finite, so is the price index. Then, by multiplying demand (6) with the product price, and integrating

[1] That is, a particular product is available if and only if one would devote infinite resources for its procuration, or pay an infinite price.

[2] We will give a more precise interpretation for m_t below.

over all m_t available products, we find that households devote all of their planned spending (5) on available products,

$$\lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} \int_0^{m_t} p_{i,t} x_{i,t} di = \lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} p_t c_t \int_0^{m_t} (p_{i,t} / p_t)^{1-\varepsilon} di = p_t c_t . \qquad (5')$$

Given nonnegativity of demand and prices, the planned spending share for any individual unavailable product is zero, which furthermore implies that individual product demand for an unavailable product must converge to zero as its price converges to infinity,

$$\lim_{p_{i,t} \to \infty} x_{i,t} = 0 , \qquad (6')$$

which, finally, allows us to derive aggregate demand c_t to equal,

$$\lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} c_t = \lim_{\{p_{i,t}\}_{m_t}^{\infty} \to \infty} [\int_0^{m_t} x_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di + \int_{m_t}^{\infty} x_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di]^{\frac{\varepsilon}{\varepsilon-1}} = [\int_0^{m_t} x_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di]^{\frac{\varepsilon}{\varepsilon-1}} . \qquad (4')$$

We have thus been able to reformulate the intratemporal consumer problem as a maximization of (4') with respect to (5'), where the difference to the original optimization problem is the length of the integral. In the transformed intratemporal problem, households are only required to make choices over all available products, ranging from zero to m_t. It is therefore a crucial question as to what determines the number of available products, m_t. Endogenous growth theory has always stressed technical factors, in particular the number of researchers developing new products, or productivity in research and development[3].
However, both demand factors and market failures may be of equal importance. Here, we shall discuss three reasons. First, consumers may refrain from consuming certain products, when they cannot judge their immediate usefulness, or because they consider them to be a danger to health. Typical examples for the prior are the telephone or the personal home computer, whereas examples for the later are pharmaceuticals, the microwave, or biotechnology products. Second, and in part as a reaction to the later, government regulation may prevent or defer entry of some new consumer products, through either health laws or product market regulation (Messina, 2000). Finally, some products may fail to succeed on the market, due to false promotion. As an example, several American fast-food

[3] A more precise formulation in the spirit of the endogenous growth literature will be presented in chapter four.

chains failed to establish themselves on European markets, when they attempted to implement the same marketing campaign as in the U.S.

The number of available products will be determined both by technical feasibility and by social feasibility. We assume that n_t products are technically feasible, whilst only m_t products are both technically and socially feasible, with $m_t \leq n_t$. Second, whilst we assume that products may be forever technically infeasible, social infeasibility is only temporary, and will vanish in the next period. In that respect, „supply shocks“ to product availability are persistent, whilst „demand shocks“ are purely transitory.

Once a product is invented, it has a specific probability φ_i to fail social acceptance, and therefore a probability of $1 - \varphi_i$ to pass social acceptance. We assume that the probability to pass social acceptance is drawn from an exponential distribution,

$$1-\varphi_i = \frac{1}{1-\tilde{\varphi}_i} e^{\frac{\in}{\tilde{\varphi}_i - 1}}, \tag{8}$$

where $\in$ is a positive random number, which is assigned to a particular innovation. $\in$ is observable, and therefore $1 - \varphi_i$ is observable as well. This is equivalent to stating that the odds whether an innovation will be successful are immediately known, whereas the actual realization is not. Note that the expected value for a particular firm equals,

$$E(1-\varphi_i) = \int_0^\infty \frac{\in}{1-\tilde{\varphi}_i} e^{\frac{\in}{\tilde{\varphi}_i - 1}} d\in = 1-\tilde{\varphi}_i, \tag{8'}$$

which we assume to be equally distributed over a random sample of innovations.

3 Firms, Wage Contracts and Entry

Each particular product variety is provided by a single firm monopolistically. They use labor as the single input, and we normalize output so that one unit of labor input yields one unit of the product. Firms therefore maximize profits, i.e. revenues $p_{i,t}x_{i,t}$ minus employment costs ω_t,

$$\pi_{i,t} = p_{i,t}x_{i,t} - \omega_{i,t}, \tag{10}$$

subject to technology, $x_{i,t} = e_{i,t}$, and demand (6). We assume that workers cannot renegotiate their wage or employment level instantaneously, but allow for full flexibility ex-ante. As there is no risk involved with incumbent firms, this does not affect decisions in these firms, and they can simply pay market wages w_t to its workforce $e_{i,t}$, hence $\omega_t = w_t e_{i,t}$.

New firms, however, face the instantaneous risk of social unfeasibility (8). As they cannot renegotiate the contract after observing their social acceptability, and as their workers cannot instantaneously hire with another firm, they offer their potential workers a contract which compensates them for the risk incurred. The risk premium may be either attached to the wage rate of workers in secure jobs, $w_{i,t} = \gamma w_t$, in which case we would observe wages above the marginal product, or by a lump-sum payment to the workers, $\sigma_{i,t}$. The later is a very common form of payment in start-up enterprises, where workers receive large parts of their income in the form of stock-options, profit shares, or bonus schemes. Hence the wage contract equals zero if marketability fails, and

$$\omega_{i,t} = \gamma w_t e_{i,t} + \sigma_{i,t}, \tag{11}$$

Profit maximization in incumbent firms yields the first order condition,

$$p_{i,t} = \tfrac{\varepsilon}{\varepsilon-1} w_t, \tag{12}$$

hence the price will equal the mark-up over (marginal employment) costs, whilst firms would have to pay marginal employment costs of γw_t. Therefore, we have at most two different prices, one for incumbent, and one for emerging firms. Hence, the price index (7') reduces to,

$$\begin{aligned} p_t &= \tfrac{\varepsilon}{\varepsilon-1}\Big[\int_0^{n_t-\dot{n}_t} w_t^{1-\varepsilon} di + \int_{n_t-\dot{n}_t}^{m_t} (\gamma w_t)^{1-\varepsilon} di\Big]^{\frac{1}{1-\varepsilon}} \\ &= \tfrac{\varepsilon}{\varepsilon-1} w_t [n_t - \dot{n}_t + \gamma^{1-\varepsilon}(m_t - n_t + \dot{n}_t)]^{\frac{1}{1-\varepsilon}} \end{aligned} , \tag{7“}$$

where $\dot{n}_t$ is change of technically feasible prices from period t - τ to t, as the time span τ converges to zero.[4] Demand for a particular product line (6), making use of the aggregate price index (7“) will therefore equal,

$$x_{i,t} = c_t [n_t - \dot{n}_t + \gamma^{1-\varepsilon}(m_t - n_t + \dot{n}_t)]^{\frac{\varepsilon}{1-\varepsilon}}, \tag{6“}$$

[4] Note that as τ converges to zero, $\dot{n}_t$ also represents the change from time t to t + τ.

which, taken to the power of $\varepsilon/(\varepsilon - 1)$, and integrated over all m_t available product lines, implies that $\gamma = 1$ by definition, or that workers cannot ask for a risk element in their wages, but have to rely on the lump-sum payment $\sigma_{i,t}$ to adjust for changes in risk. This of course implies that prices (12), quantities supplied (6"), and labor demand will be identical across all firms, incumbent and emerging. The consumption goods sector is therefore completely symmetric. The intuition behind this argument is simple. Once a firm is in operation, there is no more risk involved in working for this particular firm, and hence the risk premium should not depend on the actual amount of time spent on the job. In other words, if a firm has succeeded in placing a product on the market, its workforce cannot, despite the fact that firms lucrate monopoly rents, charge wages above the competitive level. However, workers may very well ask for compensation of the risk to sign with an emerging firm in terms of $\sigma_{i,t}$, reducing profits. Substitution of the wage contract (11) and the mark-up (12) implies that profits equal

$$\pi_{i,t} = w_{i,t} e_{i,t} /(\varepsilon - 1) - \sigma_{i,t} . \tag{10'}$$

This implies that even if profits for incumbent firms are always positive, emerging firms may chose not to proceed to enter the market early, whenever

$$w_t e_{i,t} < (\varepsilon - 1)\sigma_{i,t} . \tag{13}$$

This condition implies that firms are not only deferred from market entry by technical and social unfeasibility, but may also choose themselves to await market entry, if the risk of entry is large enough. Note that if condition (12) is binding for all new products, then no firm will try to enter the market early. Therefore, all workers would sign contracts with secure firms, and would not face the risk of unemployment. However, as it would take „time to build" new innovations, the growth rate would decline as well. A similar argument holds, of course, if condition (12) is binding only for some firms.

The minimum risk premium $\sigma_{i,t}$ that emerging firms can offer, must of course make worker indifferent between hiring with an emerging firm or an incumbent firm. Assuming that workers can pool risk over emerging firms with identical risk of market failure φ_i, instantaneous utility from wage income in risky firms and wealth must equal utility from a certain wage and wealth, or

$$\ln[E_t(1-\varphi_i)(w_t e_{i,t} + \sigma_{i,t}) + a_t] = \ln[w_t e_{i,t} + a_t] , \tag{14}$$

where workers who hire with an emerging firm receive wages and a risk premium only in the case of succeeded market entry at a probability of $1 - \varphi_i$, whilst workers in incumbent firms receive wages for sure, but no risk premium[5]. Reformulating (14) implies that the risk premium will be proportional to wage payments, or

$$\sigma_{i,t} = \frac{\tilde{\varphi}_i}{1-\tilde{\varphi}_i} w_t e_{i,t} . \qquad (15)$$

Substituting the risk premium (15) into the early-entry condition (13), we find that only firms with a probability to fail market entry below $1/\varepsilon$, will pursue early entry. In principle, the model allows for two types of firing. First, there is firing out of bad luck. Firms who fail to enter the market early will have no use of labor inputs and will therefore renege on their employment contracts. Second, there is firing for profits. If the probability to succeed market entry is sufficiently low, firms will refrain from pursuing early entry, as it would imply losses. Evidently, if the probability to fail is known ex-ante, firms will not even offer job contracts, and hence no firing will take place, In the case of a stochastic probability to fail[6], wage contracts would be signed on the basis of an expected probability to fail, and firms may be inclined to renege if they find out that the realized probability to succeed early entry falls short of the expected probability.

4 Technical Determinants of Market Entry

The innovation sector is populated by perfectly competitive R & D firms, which sell innovations to emerging service sector firms in order maximize profits. The stock of knowledge, or the level of innovations does not enter the innovation technology without cost. By contrast, innovators engage in costly activity to acquire knowledge, by forming internal or external networks. We hence assume that new varieties are created according to,

$$\dot{n}_t = \xi s_{n,t}^{\alpha} \eta_t . \qquad (16)$$

[5] Note that we are deriving this result under the assumption that households suspend savings for a single period, which is not crucial along the equilibrium path (Blanchard and Fischer, p. 42).

[6] This is equivalent to stating that $\in$ in equation (8) is unknown at the time wage contracts are signed.

Given that it is uncertain whether a single innovation will be successful, ξ measures the probability of success in innovation, when the number of attempts to innovate is large, or productivity in innovation. $s_{n,t}$ is either the amount of time a particular researcher devotes to the innovation of new products, or the number of scientists (or science mangers) engaged in innovative activities, with diminishing marginal product of innovative activities.

η_t represents networking capital, which increases with the size of the network. We can in general measure the size of a network in different ways. First, we can measure the nods of a network, or the number of participants. If there are n_t existing products, the potential number of nods in an innovation network equals n_t, hence $\eta_t = \eta(n_t)$. With n_t nods, the number of potential ties within the network would equal $(n_t - 1)!$, and if we use potential ties as a measure for the size of the network, we would have $\eta_t = \eta((n_t - 1)!)$. Finally, the number of actual ties within a network lies between n_t and $(n_t - 1)!$, hence the definition of networking capital would have to be attached to this number. All three potential measures of the size of the network depend on the number of existing innovations n_t, and we shall therefore assume for simplicity that $\eta_t = \eta(n_t)$, and that it is linear in n_t for convenience. As already mentioned, networking capital takes effort, measured in terms of employment in networking activities, $s_{\eta,t}$, with $s_{\eta,t} = s_t - s_{n,t}$, and exhibiting a diminishing marginal product as well. Hence, network capital is acquired according to the following process,

$$\eta_t = \psi n_t s_{\eta,t}^{1-\alpha}. \tag{17}$$

Productivity in networking is assumed to equal ψ. Note that innovation firms will maximize output by setting $s_{\eta,t} = (1 - \alpha)s_t$. The arrival rate of new innovations (16) can therefore be reduced to,

$$\dot{n}_t = \varphi\psi(\alpha s_t)^{\alpha}((1-\alpha)s_t)^{1-\alpha} n_t = \phi s_t n_t, \tag{16'}$$

where ϕ is a measure of productivity in the innovation sector. Given that it is uncertain whether a single innovation will be successful, ϕ measures the probability of success in innovation, when the number of attempts to innovate is large. The advantage of the specification of (16') over the traditional specification of the endogenous growth literature (16), is twofold. First, whilst endogenous growth theory has lacked a proper justification for the positive impact of existing innovations on current and future innovations[7] the explanation with networking capital gives a sound justification for this assumption. Second, whilst the parameter ψ is free in the specification (16), ranging anywhere between zero and infinity, we can obtain a clearer indication of ϕ in the specification (16'). If we assume that workers are not much more productive in innovation and networking than in the production of consumption goods, where the benchmark labor productivity is unity, we find that $\phi < 1$, since $\alpha^{\alpha}(1 - \alpha)^{1 - \alpha} < 1$.

Competitive firms in the innovation sector maximize profits. The highest price a potential service provider can pay to an innovator will equal the service firm *i*'s value, $v_{i,t}$*. The only costs for an innovator are wages w_t, paid to scientists, s_t. Hence, given technology as stated in (16'), the marginal cost for the provision of a new variety will equal its price,

$$v_{i,t}^{*} = \frac{w_t}{\phi n_t}. \tag{17}$$

5 The Market for Consumer Products and Aggregate Demand Failures

There will be four types of potential firms populating this economy at each point in time, and we will line them up systematically on the consumption good interval from zero to n_t. First, there will be $n_t - \dot{n}_t$ incumbent firms. They may have experienced a negative demand shock in the previous period, but whether they have been on the market before has no impact on their supply and demand decision today or in any period in the future. Then, there will be firms which have been refrained from pursuing early entry due to condition (13). Given that probability to fail early market entry is equally distributed over a large number of firms, the early entry condition implies that exactly $(\varepsilon - 1)/\varepsilon$ of all emerging firms will refrain from pursuing early entry, and we will group these firms towards the end of the consumption goods index interval, from $n_t - \dot{n}_t(\varepsilon - 1)/\varepsilon$ to n_t.

Finally, there will be two types of incumbent firms, which pursue early entry, those which succeed and those which fail. Given that the number of products, and hence the number of monopoly suppliers on product markets is given by m_t, we

[7] Indeed, a negative impact can be justified as well. In particular, if one assumes that the number of potential innovations is limited, and the easiest innovations have been tackled first, then a large number of already innovated products implies that it takes more and more effort to achieve an additional innovation.

assign all incumbent firms who succeed in entering the market early to the interval $[n_t - \dot{n}_t, m_t]$, and all incumbent firms who fail to enter the market early to the interval $[m_t, n_t - \dot{n}_t(\varepsilon - 1)/\varepsilon]$. Evidently, only incumbent and successful emerging firms will supply consumer goods on the market.

If the number of new innovations $\dot{n}_t$, is large, the average number of successful early entries into the consumer markets, $1 - \varphi$, will equal the actual number of early market entries,

$$(1-\varphi)\dot{n}_t = \dot{n}_t E(1-\varphi_i \mid 1-\tilde{\varphi}_i < \tfrac{\varepsilon-1}{\varepsilon}) = \tfrac{1}{2\varepsilon}\dot{n}_t, \tag{18}$$

whereas the number of firms who fail to enter the market is composed of the firms who failed to pass social acceptance, and the number of firms which have chosen not to pursue early entry, as the early entry condition (13) was binding,

$$\varphi\dot{n}_t = \dot{n}_t E(\varphi_i \mid \tilde{\varphi}_i \geq \tfrac{1}{\varepsilon}) + \tfrac{\varepsilon-1}{\varepsilon}\dot{n}_t = (1-\tfrac{1}{2\varepsilon})\dot{n}_t, \tag{18'}$$

ensuring that m_t will indeed exceed the number of past innovations $n_t - \dot{n}_t$, but fall short of the number of total innovations, n_t. This allows us to establish the number of available products on the market as,

$$m_t = n_t - \varphi\dot{n}_t. \tag{19}$$

Apart from its immediate interpretation as an aggregate failure to early market entry, φ can be given the interpretation as an aggregate demand failure, or negative demand externality. To establish this point, define potential aggregate demand, c_t*, as the ceteris paribus level of aggregate demand that would prevail in the absence of a positive probability to fail early entry to the market, holding everything else, in particular consumption goods sector employment, equal,

$$c_t^* = [\int_0^{n_t} x_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di]^{\frac{\varepsilon}{\varepsilon-1}} = n_t^{\frac{\varepsilon}{\varepsilon-1}} x_{i,t} = (n_t / m_t)^{\frac{1}{\varepsilon-1}} c_t = (1-\varphi\hat{n}_t)^{\frac{1}{\varepsilon-1}} c_t. \text{ (4“)}$$

First, in the absence of economic growth, actual aggregate demand c_t will equal potential aggregate demand, c_t*, for any value of the average failure rate to early entry, $1 - \varphi$, since entry will not occur in that case. Second, despite the fact that the demand shock is purely temporary, and only instantaneously affects demand, actual demand will always fall short of potential demand in a growing economy. Third, an increase in φ widens the gap between actual and potential output, as

$$\frac{\partial c_t / c_t^*}{\partial \varphi} = -\tfrac{\varphi}{\varepsilon-1}(1-\varphi\hat{n}_t)^{\frac{1}{\varepsilon-1}-1} < 0 .$$

Finally, actual output will equal potential if and only if $\varphi = 0$, hence φ describes an aggregate demand externality. Hence, social acceptance of products influences the outcome of the economy despite its purely transitory nature, as it distorts the decision of firms, which take potential failures into consideration.

6 Unemployment and the Labor Market

Ex-ante equilibrium will be ensured if every single worker will be either offered a secure wage contract in an innovation firm or in an incumbent consumer goods firm at wage w_t, or an insecure contract in an emerging consumer goods firm, were the wage contract would include a risk premium. If we define the total number of labor contracts offered in the consumer goods sector by e_t^*, the labor market clears ex-ante if and only if $e_t^* + s_t = 1$, the total labor supply. Potential (or ex-ante) employment in the goods market is defined as the integral over all n_t individual monopoly suppliers of consumption goods,

$$e_t^* = \int_0^{n_t} e_{i,t} di = \int_0^{n_t - \dot{n}_t} e_{i,t} di + \int_{n_t - \dot{n}_t}^{n_t - \varphi\dot{n}_t} e_{i,t} di + \int_{n_t - \varphi\dot{n}_t}^{n_t - \dot{n}_t + \dot{n}_t / \varepsilon} e_{i,t} di + \int_{n_t - \dot{n}_t + \dot{n}_t / \varepsilon}^{n_t} e_{i,t} di , \tag{20}$$

were we have split the integral into four parts two capture different phases of the product life cycle. The first integral from zero to $n_t - \dot{n}_t$ captures employment of incumbent firms. The second and the third integral in equation (18) contain employment contracts offered by emerging firms which have pursued early entry, where we have used equation (19) to define the borders of integration. The last integral captures firms we have been refrained from pursuing early entry be condition (13), and corresponds to firing for profits. Given that probability to fail early market entry is equally distributed over a large number of firms, the early entry condition implies that exactly $(\varepsilon - 1)/\varepsilon$ of all emerging firms will refrain from pursuing early entry, explaining the lower border of integration in the last integral. As these firms know ex-ante that pursuing early entry will be unprofitable, they will not offer any labor contracts, and the last term in equation (20) equals zero. Given symmetry on the consumption goods market, potential employment will therefore equal,

$$e_t^* = \int_0^{n_t - \dot{n}_t + \dot{n}_t / \varepsilon} e_{i,t} di = (1 - \hat{n}_t + \hat{n}_t / \varepsilon) n_t e_{i,t} = 1 - s_t = 1 - \frac{\hat{n}_t}{\phi}, \qquad (18')$$

Note that this implies that potential employment is constant for a constant rate of growth. But then we find that potential aggregate demand (4") will equal,

$$c_t^* = n_t^{\frac{1}{\varepsilon - 1}} (n_t e_{i,t}), \qquad (4''')$$

where the term in parenthesis is constant for a constant growth rate, due to equation (18'). Taking time derivatives, we find that the growth rate of potential consumption is equal to (ε - 1) times the growth rate of innovations. The same holds for the growth rate of actual aggregate consumption, from substitution of (4''') and (19) into equation (4").

Consumer good manufacturers who fail early entry will evidently renege their signed labor contracts, rendering their potential employees unemployed. As there will be no firing in the innovation sector, an ex-ante clearing labor market implies that unemployment must be the difference between potential employment and actual employment in the consumption goods sector,

$$e_t = e_t^* - u_t = \int_0^{n_t - \varphi \dot{n}_t} e_{i,t} di = (1 - \varphi \hat{n}_t) n_t e_{i,t} = 1 - u_t - s_t = 1 - u_t - \frac{\hat{n}_t}{\phi}, \qquad (18")$$

The unemployment rate is therefore defined by the third integral of equation (18), which, given the models symmetry of employment demand, equals

$$\begin{aligned} u_t &= \int_{n_t - \varphi \dot{n}_t}^{n_t - \dot{n}_t + \dot{n}_t / \varepsilon} e_{i,t} di = (\varphi - \tfrac{\varepsilon - 1}{\varepsilon}) \dot{n}_t e_{i,t} = (\varphi - \tfrac{\varepsilon - 1}{\varepsilon}) \hat{n}_t \frac{1 - \hat{n}_t / \phi}{1 - \frac{\varepsilon - 1}{\varepsilon} \hat{n}_t} \\ &= (\varphi - \tfrac{\varepsilon - 1}{\varepsilon}) \frac{\varepsilon - 1}{\phi} \hat{c}_t \frac{\phi - (\varepsilon - 1) \hat{c}_t}{1 - \frac{(\varepsilon - 1)^2}{\varepsilon} \hat{c}_t} \end{aligned} . \qquad (21)$$

Equation (21) describes a relationship between the economic rate of growth and the unemployment rate. As it is derived from both the workers incentive to sign with risky but lucrative jobs in emerging firms, and by the emerging firm's incentive to renege contracts, once the innovation has proven to be a temporary failure on the market, we shall call this locus the incentive constraint. It passes through the origin, implying that we have zero unemployment with zero growth, which is a situation when innovation is too costly to be undertaken at all. It also exhibits zero unemployment at a growth rate of $\phi/(\varepsilon - 1)$, which is when early entry is so costly that no firm will take the chance. The incentive constraint (21) is hump-shaped in between the nulls, with a maximum unemployment rate that would exceed unity, hence only the upward sloping part of the incentive constraint will be of economic relevance. This allows us to linearize the incentive constraint (21) using a first-order MacLaurin expansion,

$$u_t = (\varphi - 1 + \tfrac{1}{\varepsilon})(\varepsilon - 1)\hat{c}_t . \qquad (21')$$

Despite the fact that labor market rigidities are very limited, and concern only a fraction of the emerging firms, equation (21'), together with (18) implies that the unemployment rate equals the economic growth rate divided by twice the mark-up (12). Hence, for a three percent growth rate and a 25 % mark-up, the model helps to explain 1,2 % percentage points of the unemployment rate.

7 Economic Growth and Venture Capital Markets

Innovators will have to finance there activities on bond markets. The maximal price they can achieve for an innovation equals the discounted stream of profits, which the monopoly supplier of the product can lucrate on product markets. Given the symmetry of the consumption sector, the profit stream will be identical for all incumbent firms. Emerging firms, however, have to pay a risk premium out of their running profits, and still face the risk of market failure, so that their first period profits, and hence their market value, will be below the equivalent of an incumbent firm,

$$v_{i,t}^* = \int_t^\infty \pi_{i,t}^* e^{-r(\tau-t)} d\tau = E_t \pi_{i,t}^* - \pi_{i,t} + \int_t^\infty \pi_{i,t} e^{-r(\tau-t)} d\tau = E_t \pi_{i,t}^* - \pi_{i,t} + v_{i,t} , \qquad (22)$$

where stars (*) denote values of emerging firms, and variables without stars correspond to the according values of incumbent firms. Equation (22) describes an intratemporal no-arbitrage condition. It states that you trade a bond of an incumbent firm, $v_{i,t}$*, against a bond of an emerging firm if and only if you are compensated for the loss in expected dividends, i.e. profits, in the first period. As incumbent firms will make first period profits and pay risk premia only in the case of success in marketing its product, we can reformulate the intratemporal no-arbitrage condition (22),

$$v_{i,t} = v^{*}_{i,t} + \tilde{\varphi}_i \pi_{i,t} + (1-\tilde{\varphi}_i)\sigma_{i,t} = \frac{w_t}{\phi n_t} + \tilde{\varphi}_i \varepsilon \pi_{i,t}, \text{ (22')}$$

where we have eliminated the expectation operator and the risk premium with equation (15), and the value of an incumbent firm with equation (17). Apart from incumbent and emerging firms, even firms who were refrained from early market entry by condition (13) have a value on the stock market, as they all benefit from a future stream of monopoly rents. Therefore, total stock market capitalization equals,

$$v_t = \int_0^{n_t} v_{i,t} di = \int_0^{n_t - \dot{n}_t} v_{i,t} di + \int_{n_t - \dot{n}_t}^{n_t - \dot{n}_t + \dot{n}_t/\varepsilon} v_{i,t} di + \int_{n_t - \dot{n}_t + \dot{n}_t/\varepsilon}^{n_t} v_{i,t} di, \qquad (23)$$

where we have split the integral into incumbent firms, emerging firms, and innovators who have opted not to pursuit early market entry. An incumbent firm is certain that its innovation exhibits a market, therefore its valuation on the stock market should simply equal opportunity costs of innovating a new product (17). By contrast, a firm which has chosen not to pursue early entry has to forgo in addition current profits. Finally, emerging firms face the risk of failing market, in which case they would not lucrate running profits, but would also not have to pay risk premia. Making use of equations (17), (10), (15), (20'), and (18'), we find that aggregate stock market capitalization depends on the growth rate, wages, and unemployment only,

$$v_t = \frac{w_t}{\phi} + (\varphi + \varepsilon - 1)\hat{n}_t \int_0^{n_t} \pi_{i,t} di. \qquad (23')$$

Whilst the first term in equation (23') is well known from the endogenous growth literature, and expresses the fact that innovations occur until revenues equal costs. The second term equals the hypothetical losses of early market failures, where a fraction φ of the emerging firms will fail early entry, thus loosing their profits, and a the remaining ($1 - \varphi$) emerging firms will pay a fraction of (ε - 1)/($1 - \varphi$) of their profits as risk premia. It implies that as compared to the technologically determined growth models, aggregate stock market capitalization is lower here. Evidently, as the growth rate of varieties increases, the gap between potential and actual aggregate stock market capitalization widens, as the chances to incur losses increase. The second term states that as products become closer substitutes, ε increases, running profits decline, and hence the early entry condition eliminates a larger share of potential early entrants. Finally, note that aggregate stock market capitalization, v_t, increases as the growth rate of varieties increases. Evidently, if an economy becomes more innovative, stock markets will tend to boom, which can account for this aspect of the new economy (Zagler, 1999).

Whilst equation (22') describes an intratemporal tradeoff between different types of stocks, arbitrage on stock and bond markets should also lead to an intertemporal tradeoff. In particular, investors should be indifferent between investing an amount v_t into company stocks, which yields both dividends, i.e. running profits, and value gains, and a safe asset, which yields interest $r_t v_t$,

$$\dot{v}_{i,t} + \pi_{i,t} = r_t v_t . \tag{24}$$

Dividing both sides by v_t, noting from equation (17) that the growth rate of a particular bond is equal to the difference between the growth rate of wages and innovations, and from integration of the intertemporal budget constraint that wages and consumption grow at the same rate, eliminating the interest rate from the intertemporal Euler condition (3), integrating over all n_t firms, we find upon rearrangement,

$$v_t = \frac{1}{\hat{n}_t + \rho} \int_0^{n_t} \pi_{i,t} di , \tag{24'}$$

which states that aggregate stock market capitalization equals potential profits, discounted at the individual rate of time preference and the innovation rate, or the degree of supersession of a particular product from the market. Eliminating the aggregate stock market capitalization from the aggregate intratemporal no-arbitrage condition (24'), and aggregate profits from equation (10') and (20'), we obtain a relation between the rate of innovation and the unemployment rate,

$$\Phi(\hat{n}_t) \equiv (\varepsilon - 1)(\hat{n}_t + \rho) + \varphi\varepsilon\hat{n}_t(\hat{n}_t + \rho) + \hat{n}_t = \phi(1 - u_t) , \tag{25}$$

which, as it was derived from both limited resources on the labor and capital markets, can be referred to as a resource constraint. The function $\Phi(.)$ is decreasing in unemployment. The first term in the resource constraint (25) corresponds to the discount rate on emerging firms profits, as can be easily deduced from equations (24') and (18). It states that as profits gets discounted faster, firms will sooner defer from pursuing early entry, and thus reducing the unemployment rate. The third term corresponds to the resource drain from the innovation sector. As the innovation sector offers more secure jobs, the labor resource base for the consumption goods sector declines, implying that reneging of labor contracts by emerging firms will affect less and less workers, thus reducing unemployment. The term in the center, finally, is an interaction term, which states that as the number of new innovations increases, a large portion of the consumption goods sector workforce will be employed in emerging firms, which evidently increases unemployment. Given that both the growth rate of innovations and the individual rate of time preference ρ are both small, the interaction term will be only of second-order importance, and we shall therefore ignore it in the following, yielding a second relation between the rate of economic growth and the unemployment rate,

$$\hat{c}_t = \frac{\phi(1-u_t)}{\varepsilon(\varepsilon-1)} - \frac{\rho}{\varepsilon}. \tag{25'}$$

8 Equilibrium Unemployment and Economic Growth

The economy can be fully described by two linearized relations in the rate of economic growth and the unemployment rate, that is the incentive constraint (21') and the resource constraint (25'). This allows us to solve for the equilibrium unemployment rate as a function of the deep parameters of the model only,

$$u_t = \frac{(\varphi - \frac{\varepsilon-1}{\varepsilon})[\phi - \rho(\varepsilon-1)]}{\varepsilon + \varphi - \frac{\varepsilon-1}{\varepsilon}}, \tag{25}$$

and simultaneously for the balanced rate of economic growth, which equals,

$$\hat{c}_t = \frac{\phi - \rho(\varepsilon-1)}{\varepsilon(\varepsilon-1) + \phi(\varepsilon-1)(\varphi - \frac{\varepsilon-1}{\varepsilon})}. \tag{26}$$

This leads to several comparative static conclusions. First, an increase in the individual rate of time preference, unsurprisingly, reduces the rate of economic growth. In addition, however, it also contributes to lowering the equilibrium rate of unemployment. As people become more patient, they acquire a more conservative consumption profile, demanding less innovative products, and hence reducing the scope for failures in early market entry. Second, an increase in the innovation sector's productivity fosters economic growth, as an identical share of innovation sector workers will produce a greater number of innovations,

$$\frac{\partial \hat{c}_t}{\partial \phi} = \frac{(\varepsilon-1)[\varepsilon+\rho(\varepsilon-1)(\varphi-\frac{\varepsilon-1}{\varepsilon})]}{[\varepsilon(\varepsilon-1)+\phi(\varepsilon-1)(\varphi-\frac{\varepsilon-1}{\varepsilon})]^2} > 0\,.$$

However, this implies that workers are freed from innovative activities, and move particularly into emerging sector firms, were the risk of unemployment is high, thus increasing the equilibrium rate of unemployment,

$$\frac{\partial u_t}{\partial \phi} = \frac{(\varphi-\frac{\varepsilon-1}{\varepsilon})}{\varepsilon+\varphi-\frac{\varepsilon-1}{\varepsilon}} > 0\,.$$

An increase in the price elasticity of demand ε, unambiguously reduces economic growth, since

$$\frac{\partial \hat{c}_t}{\partial \varepsilon} = \frac{-\rho[\varepsilon(\varepsilon-1)+\phi(\varepsilon-1)(\varphi-\frac{\varepsilon-1}{\varepsilon})]-[\phi-\rho(\varepsilon-1)][2\varepsilon-1+\phi(\varphi-\frac{\varepsilon-1}{\varepsilon})-\phi\frac{\varepsilon-1}{\varepsilon^2}]}{[\varepsilon(\varepsilon-1)+\phi(\varepsilon-1)(\varphi-\frac{\varepsilon-1}{\varepsilon})]^2} < 0$$

Evidently, as innovations yield lower rents, they will induce lower innovative effort, thus reducing the economic growth rate. In conventional endogenous growth models, this would reallocate the workforce towards an increased production of consumption goods, thus raising profits despite lower profit shares, and hence the effect is ambiguous. Here, the partial deferment of current running profits due to a demand constraint is sufficient to render the effect negative. Whilst reducing the mark-up will reduce the growth rate of the economy, it will improve the employment situation, as

$$\frac{\partial u_t}{\partial \varepsilon} = -\frac{(\varphi-\frac{\varepsilon-1}{\varepsilon})\rho+u_t}{\varepsilon+\varphi-\frac{\varepsilon-1}{\varepsilon}} < 0\,.$$

Here, the lower number of innovations reduces the risk of getting a job offer from an emerging firm, and hence reduces unemployment.

Finally, an increase in the magnitude of the transitory demand shock will increase the aggregate demand externality φ, which in turn directly leads to an increase in the unemployment rate, as can be observed from equation (21'), and persists in the general equilibrium, as

$$\frac{\partial u_t}{\partial \varphi} = \frac{\varepsilon[\phi - \rho(\varepsilon - 1)]}{\varepsilon + \varphi - \frac{\varepsilon - 1}{\varepsilon}} > 0 .$$

However, the increase in the aggregate demand externality will distort decision by firms to defer market entry, rendering less innovations lucrative at any given point in time, thus an increase in φ unambiguously reduces the economic growth rate indirectly,

$$\frac{\partial \hat{c}_t}{\partial \varphi} = \frac{-\phi(\varepsilon - 1)[\phi - \rho(\varepsilon - 1)]}{[\varepsilon(\varepsilon - 1) + \phi(\varepsilon - 1)(\varphi - \frac{\varepsilon - 1}{\varepsilon})]^2} < 0 .$$

This last effect sheds new light on the discussion of unemployment benefits. As all the distortion in firms decisions stem from the risk premium which workers ask to compensate the risk of loosing a job, unemployment benefits will reduce the size of the risk premium, thus fostering economic growth, but by the same token also raise the level of unemployment. In order to eliminate the entire distortionary effect, unemployment benefits are required to drive the reservation wage up to the current wage rate. The duration of unemployment benefits can, however be short, given that labor contracts only take a short time to renegotiate.

Summarizing, we find that an increase in the individual rate of time preference, a decrease innovation productivity and a decline in profit shares all reduce growth and unemployment, whereas a decrease in the demand externality, equivalent to an increase in aggregate failure to enter the market early, reduces growth and fosters unemployment. Therefore, whilst all growth determinants addressed by the endogenous growth literature, namely preferences, represented by the parameters ρ and ε, and technology, represented by innovation productivity ϕ, lead to a positive correlation between growth and unemployment, only shifts in aggregate demand can account for the intuitive negative correlation between growth and unemployment, as asserted in the empirical literature ever since Okun (1970). Whereas the individual rate of time preference, the elasticity of substitution, and innovation productivity may account for situations of jobless growth, only a wicked combination of these parameters, or an aggregate demand externality, can explain situations of high growth and low unemployment.

9 Conclusions

This paper has argued that in a growing economy unemployment can be the cause of goods markets failures, even if these are purely transitory. As the economy grows, new firms wish to enter product markets. It may take some time, however, until their products are accepted on the market, which we model as a purely transitory demand shock. This can either be due to consumers' choice to defer immediate consumption of certain products, in particular if they consider them to be dangerous to health, because of failures in the marketing of the product, or finally because of government regulation, deferring entry into the product markets.

Firms who fail early entry will renege on the job offers, causing unemployment. Workers, anticipating this, will ask for a risk premium in insecure contracts, distorting price and supply decisions of firms, reducing incentives to invest into novel products, which reduces, but does not eliminate the number precarious job offers. Thus a transitory demand shock will lead to a persistent level of unemployment in a growing economy. Moreover, shifts in the aggregate demand externality are the only unique factor which can account for a negative correlation between the economic rate of growth and the unemployment rate, which is line with empirical observations. Therefore, the introduction of aggregate demand externalities is important to explain the joint determinants of economic growth and unemployment.

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