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Heterogeneous productivity shocks, elasticity of substitution and aggregate fluctuations ☆

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ABSTRACT

We use a Dixit-Stiglitz setting to show that aggregate productivity fluctuations can be generated through changes in the dispersion of firms' productivity. When the elasticity of substitution among goods is larger than one, an increase in the dispersion raises aggregate productivity because firms at the top of the distribution produce most of output. When the elasticity is smaller than one, an increase in the dispersion reduces aggregate productivity because firms at the bottom of the distribution use most of inputs. We use individual firm level data from Spanish manufacturing firms to test the relationship between the dispersion of firms' productivity and aggregate productivity. The estimated coefficients are consistent with the predictions of the model: we find that an increase in the coefficient of variation of firms productivity of 1% increases aggregate productivity by 0.16% in sectors with an elasticity of substitution larger than one while the same increase in the standard deviation reduces aggregate productivity by 0.36% in sectors with an elasticity of substitution smaller than one.

1. Introduction

In this paper we study the relationship between a time varying distribution of firms idiosyncratic productivity and aggregate productivity fluctuations. We first use a simple general equilibrium model with Dixit-Stiglitz indices to show that when the elasticity of substitution among a large number of goods is different from one, aggregate productivity is different from the average productivity of firms producing those goods. This implies that even if the deterministic part of firms productivity is equal to one and firms receive i.i.d. shocks from a common probability distribution function, aggregate productivity is different from one.

This result follows from the fact that the elasticity of substitution determines consumers' willingness to change the purchases ratio of two goods when the price ratio of those goods changes. If the elasticity is high, consumers switch from one good to another for small price changes. When the elasticity is small, it takes high price differentials to induce consumers to

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slightly change the bundle of goods they are consuming. Thus, a low elasticity of substitution implies that production is distributed evenly across producers. If this is the case, low productivity firms have a large impact on the productive capacity of the economy and therefore aggregate productivity is low. On the other hand, when the elasticity of substitution is high, output is produced mostly by high productivity firms and aggregate productivity is large. Put it differently, the share of more productive firms in industry revenue increases with the degree of substitutability of products. It follows that, since aggregate productivity can be seen as an output-weighted average of firms productivity, it increases with the elasticity of substitution among products.

An implication of an elasticity of substitution different from one is that, even when the mean of the distribution does not change, changes in the shape of the distribution of firms' productivity have the same effect of an aggregate shock hitting the productivity of all firms. Although this paper does not provide a theory of the time variation of the distribution of firms' productivity, there is little reason to suppose that this distribution is stable over time. On the empirical side, Bloom et al. (2012) provide evidence suggesting that the variance of establishment, firm and industry level shocks in the U.S. is countercyclical. Kehrig (2011) shows that the dispersion of the level of firms productivity in U.S. manufacturing is counter-cyclical and it is more pronounced in durables than in non-durables. Bachman and Bayer (2009), using a panel of public and private German firms in manufacturing and retail, find that the variance of innovations to firms' productivity increases in recessions. In this paper, we provide evidence that the variance of the distribution of firms productivity in Spanish manufacturing sectors varies sensibly over time. It follows that the interaction between a time varying productivity distribution and an elasticity of substitution different from one provides a source of fluctuations in aggregate productivity without the need to assume a common (aggregate) shock to the productivity of all firms, or an input–output matrix that transmits sectoral shocks across sectors.

A crucial point here is that, depending on the elasticity of substitution, an increase in the dispersion of firms' productivity can have either a positive or a negative effect on aggregate productivity. When the elasticity is smaller than one, an increase in the dispersion has a negative effect, while the opposite holds with an elasticity larger than one. This happens because an increase in the dispersion implies that there are more high productive firms and more low productive firms. If the elasticity of substitution is high, most productive firms employ most of inputs and produce most of output so when their number increases aggregate productivity also increases. When the elasticity of substitution is low, demand tends to be distributed evenly among producers, so an increase in the number of low productive firms reduces aggregate productivity because these firms use most of inputs.

To test the predictions of the model we use data from 18 Spanish manufacturing sectors. We first estimate the elasticity of substitution among goods in each sector. This is smaller than one in 14 sectors and larger than one in 4 sectors. With the estimated elasticity of substitution we are able to construct, for each sector, the relevant measure of aggregate productivity. According to the model, sectors with an elasticity of substitution larger (lower) than one show an increase (decrease) in aggregate productivity when the dispersion of the productivity distribution increases. We test this implication in a regression framework. We regress aggregate productivity of each sector on the coefficient of variation of productivity in each sector and the interaction between the coefficient of variation and a dummy variable that takes value one if the sector has an elasticity of substitution larger than one. The estimated coefficients are consistent with the predictions of the model; we find that an increase of 1% in the coefficient of variation of the distribution of firms' productivity increases aggregate productivity by 0.16% in sectors with an elasticity of substitution larger than one while the same increase in the coefficient of variation reduces aggregate productivity by 0.36% in sectors with an elasticity of substitution smaller than one.

We are not the first to investigate the effects of a time varying dispersion of firms' productivity on aggregate fluctuations. The already mentioned papers by Bachman and Bayer (2009), Bloom et al. (2012) and Kehrig (2011) provide fully-fledged general equilibrium models that allow to study these effects. Bloom et al. (2012) show that when labor and capital adjustment costs are present, uncertainty shocks make firms more cautious, thus delaying hiring and investment, which in turn depresses aggregate productivity and economic activity. Bachman and Bayer (2009) instead, stress the "news" role of changes in uncertainty in shaping aggregate fluctuations. Kehrig (2011) presents a model with overhead inputs–that become more expensive in booms–and entry and exit of firms. In equilibrium, only the most productive new firms enter and only the most productive incumbents survive during economic expansions.[1] Compared to these contributions, we identify a new channel through which changes in the dispersion of firms' productivity can lead to aggregate fluctuations. This is solely grounded in the elasticity of substitution among goods.[2]

This paper also contributes to two other strands of the literature: the one that studies the existence of persistent productivity differences among firms and the one that studies how the distribution of resources among firms affects aggregate productivity. Within the former, a closely related paper is Syverson (2004), who investigates the role of the elasticity of substitution on observed differences in plant level productivity. He points out, focusing on the concrete market, that barriers to substitutability of any kind (spatial, physical or brand driven) among producers, allow less productive firms to survive,

[1] See also Heathcote et al. (2014), who present a model in which the dispersion of wages across individuals is time varying.

[2] More broadly, our paper also relates to the literature on the ability of models with a large number of sectoral shocks to generate aggregate fluctuations. Lucas (1981) and Dupor (1999) suggest that when the economy is sufficiently disaggregated, independent sectoral shocks wash out in the aggregate because of the law of large numbers. Instead, Horvath (1998), and in particular Acemoglu et al. (2012), show that the response of the aggregate economy to a large number of sectoral shocks depends on the input–output structure of the economy.