EUI WORKING PAPERS IN ECONOMICS

EUI Working Paper ECO No. 95/14

Thick-Market Externalities in U.S. Manufacturing: A Dynamic Study with Panel Data

MIGUEL JIMÉNEZ
and
DOMENICO MARCHETTI, JR.

European University Institute, Florence

EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ECONOMICS DEPARTMENT

EUI Working Paper **ECO** No. 95/14

Thick-Market Externalities in U.S. Manufacturing: A Dynamic Study with Panel Data

MIGUEL JIMÉNEZ
and
DOMENICO MARCHETTI, JR.

BADIA FIESOLANA, SAN DOMENICO (FI)

Printed in Italy in May 1995
European University Institute
Badia Fiesolana
I – 50016 San Domenico (FI)
Italy

Thick-Market Externalities in U.S. Manufacturing: A Dynamic Study with Panel Data

Miguel Jiménez, European University Institute
Domenico Marchetti, jr. *
Cornell University and Bank of Italy

Abstract

This paper investigates the effect of the business cycle on productivity. We apply a VAR methodology to a panel data set of 402 four-digit U.S. manufacturing industries. In order to distinguish between (i) effort variation effects and (ii) thick-market effects à la Diamond (1982) and other "true" productive externalities, if any, we simulate a permanent demand-induced increase of aggregate economic activity, and analyze the dynamic response of sectoral productivity. Our results support the existence of supply-side externalities, and therefore point to them as a potential source of social increasing returns and multiple equilibria. In addition, unlike some recent papers by Gali and Hammour (1993) and Saint-Paul (1993), we find no evidence of negative long-run effects of expansions on productivity.

*This paper was written when D. Marchetti was a visiting researcher at EUI, whose support is gratefully acknowledged. The views expressed herein are those of the authors, and do not necessarily reflect those of the Bank of Italy. We thank Robert Waldmann and seminar participants at EUI for valuable comments; Fabio Canova and Douglas Holtz-Eakin for useful discussions at a preliminary stage of our research. Data were provided by Eric Bartelsman and John Fernald. We also thank Professor Jorgenson for letting us use his data.

1 Introduction

In an original contribution to the theory of business cycle, Diamond (1982) –by introducing the exchange mechanism into a formal model– has described one channel through which the level of aggregate economic activity can affect productivity of individual firms at business cycle frequencies. In his model, higher activity levels result in higher probabilities of matching among compatible agents. This is the leading model of so-called –and highly controversial– "thick-market" effects. That the output of individual firms and industries is higher in places and at times when economic activity is more concentrated is hardly deniable. The question is rather if –at business cycle frequencies– such externalities are mainly on the demand side, or the production side. "Pecuniary" or demand externalities have a much stronger tradition in economics. They were behind the Keynesian multiplier theory, and drive recent models of imperfect competition and multiple equilibria, like those by Kiyotaki (1988) and Murphy et al. (1989). On the other hand, theoretical discussion of technological externalities has not made much progress after Diamond's (1982) contribution. However, they fit well in Weitzman's (1982) broad concept of increasing returns, and have been explicitly formalized in Durlauf's (1991) model of localized technological complementarities and multiple equilibria. In general, thick-market (or trading) externalities provide a supply-side rationalization for the increasingly popular assumption of costant returns at firm level combined with industry(or economy)-wide increasing returns.

On the empirical side, technological externalities have attracted much attention from the recent controversy on the source of procyclical productivity. In fact, in a widely-cited paper, Caballero and Lyons (1992) have suggested that procyclical productivity is due to high-frequency external effects from aggregate activity, besides the traditional labor hoarding effects, advocated by Rotemberg and Summers (1990) and Bernanke and Parkinson (1991). Caballero and Lyons' results have been changelled, thereafter, by Basu and Fernald (1993) and Marchetti (1994), on grounds of model misspecification and data shortcomings. However, Bartelsman, Caballero and Lyons (1994) have offered new evidence on thick-market effects, with more disaggregated data.[1]

This paper investigates the nature and empirical relevance of the effect of aggregate economic activity on productivity. We make use of a dynamic model, and apply it to a panel data set of 402 four-digit U.S. manufacturing industries. We use gross output data, and data on four inputs –i.e., production labor, non-production labor, capital and intermediate inputs. Our data set covers the period 1958-84.

In practice, the analysis of the effect of the business cycle on productivity is significantly complicated by measurement errors which typically affect data on labor input. In fact, as it is well-known, if labor effort varies over the cycle –as it does– productivity measures can be highly biased and misleading (see for example Abbott et al., 1989, and Gordon, 1990). Positive effort variations result in apparent productivity increases, which add up to true external effects, if any. Furthermore, although effort-adjusted productivity measures have been used in some studies (see Gali and Hammour, 1993, and Saint-Paul, 1993), it is important to recognize that all attempts to correct productivity measures for effort variations are arbitrary to some extent, given the lack of detailed information on the matter. [2]

Rather than using effort-adjusted productivity measures, we follow Sbordone's (1992) dynamic approach to identify effort variation vs. thick-market effects, while using standard, unadjusted Solow residuals. The method is the following. We simulate a permanent increase of aggregate activity in a VAR model, and investigate over time the induced change in sectoral productivity. As time passes, effort variation effects will die out, whereas "true" trading and technological externalities will not vanish. Detection of a persistent positive effect on productivity level, therefore, is interpreted as evidence of thick-market externalities.

Our approch is also readily interpretable within the structural Vec-

[1]Yet, such results might also be affected, to some extent, by the limitations of the data that they use. See Norbbin (1993, pages 1149-54).

[2]For a careful analysis of effort variations over the cycle and a discussion of related proxies, see Shea (1991). On labour hoarding, see Fay and Medoff (1985).

tor Autoregression literature, since it shares some features with models of the kind introduced by Blanchard and Quah (1989). However, the specification and identification of our model differs significantly from theirs. Indeed, Blanchard and Quah's identification would not be appropriate within our model, since it is inconsistent with endogenous productivity. Instead, we choose an identification approach which is similar, in spirit, to that introduced by Stockman (1988). That is, we (implicitly) assume that business cycles are driven by two kinds of disturbances, uncorrelated with each other, respectively aggregate and sectoral disturbances. Aggregate shocks can be readily interpreted as mainly real aggregate demand shocks, plus aggregate supply shocks (such as the oil price shocks), while sectoral shocks represent "pure" technological shocks, in the real business cycle tradition. [3] By following again Sbordone (1992), we identify the model by assuming that sectoral technological shocks do not affect contemporaneously aggregate activity growth, due to the limited dimensions of each industry vis-a-vis the whole manufacturing sector. This assumption seems to us quite reasonable, since we use data on four-digit SIC level industries. Indeed, the use of sectoral data is the other feature of our model that differs from the structural VAR literature, since we use panel data for estimating the VAR coefficients.

We find some evidence of labor-hoarding effects and, more interestingly, thick-market externalities, in the above sense. That is, we find that permanent increases in aggregate activity –other than those due to technological shocks– have a persistent positive effect on productivity. Furthermore, an extension of our base model –which disentangles aggregate demand shocks from oil price shocks– shows that our results cannot be simply attributed to the latter.

Our findings help also to clarify a closely related issue. Some recent theoretical papers have emphasized the positive effects that recessions may have on productivity, through a number of channels. Ca-

[3]Note that the assumption of sectoral –rather than aggregate– technological shocks follows closely the leading multi-sectoral real business cycle model –i.e., Long and Plosser (1983). Furthermore, this assumption is consistent with any accurate historical account of technological progress, which is almost by its nature industry-specific, and then eventually spreads out across sectors. See Rosenberg (1982).

ballero and Hammour (1991) have used a model of creative destruction to show that recessions have "cleansing" effects on outdated techniques and products. Hall (1991) has emphasized the role of "organizational" capital, whose accumulation would increase during slumps. These and other studies (see also Bean, 1990, and Aghion and Saint-Paul, 1991) rely on intertemporal substitution of productivity-improving activities along the cycle. Recently, two empirical studies –by Gali and Hammour (1993) and Saint-Paul (1993)– have provided evidence supporting such theories. According to their results, any positive effects of expansions on productivity are more than offset by negative ones, and expansions have a negative net effect on productivity in the long run.

Our results are quite different. Indeed, we find that the long run effect of booms on sectoral productivity is positive in manufacturing as a whole and in most two-digit manufacturing industries (although very close to zero in the remaining industries). The difference between our results and the cited ones is most probably due to the way the respective models are identified. To this regard, Gali and Hammour and Saint-Paul identify demand shocks as those which have no contemporaneous effect on productivity. Even leaving aside thick-market effects (which are assumed away within their identification), such assumption strictly requires the use of productivity measures adjusted for effort variations. However, as mentioned above, deriving such measures is quite an arbitrary task. Ultimately, therefore, the reliability of Gali-Hammour and Saint-Paul identification approach hinges upon that of such adjustments.

Finally, we performed a number of robustness tests. In particular, we repeated our estimations for each industry at 2-digit SIC level, testing the significance of the long run response of productivity growth to aggregate shocks using the sequential Bonferroni approach. We also tested if our results were sensible to the aggregation level or other features of the data used. Corroborative evidence was found using Jorgenson et al.'s (1987) quality-unadjusted two-digit data.

The remainder of the paper is organized as follows. Section 2 introduces the basic model to be used in our analysis. A brief description of the data can be found in Section 3. Results are discussed in Section

4, and conclusions follow.

2 A VAR Model of Productivity and the Business Cycle

In this section we introduce our basic model. As mentioned in the introduction, we intend to analyze the dynamic effect of aggregate economic activity on productivity. To this purpose, we use a Vector Autoregressive approach.

We characterize the joint dynamics of our main variables –the rate of growth of, respectively, aggregate economic activity, ΔY, and sectoral productivity, Δs_i– as a stationary two-variable vector autoregressive process of order one. Our measures of the variables are the rate of growth of aggregate manufacturing output, and the sectoral (four-digit level) gross output Solow residual.

More formally, let X(t) be the vector $(\Delta Y, \Delta s_i)$', and u(t) a two-dimension white noise process. We assume that X(t) follows a stationary stochastic process, with the following canonical moving average representation:

$$\begin{aligned} X(t) &= \Phi(0)u(t) + \Phi(1)u(t-1) + ... \\ &= \sum_{i=0}^{\infty} \Phi(i)u(t-i), \end{aligned}$$

where Var(u)=Ω and $\Phi(0) = I$.[4]

As it is well known, such process can be also expressed in terms of orthogonal or fundamental residuals. Let e(t) be the vector $(e_a, e_s)'$, where e_a and e_s are, respectively, aggregate and sectoral disturbances, independent to each other. Then X(t) can be expressed as:

[4]For simplicity, we are dropping the vector of means from the representation.

$$X(t) = \Theta(0)e(t) + \Theta(1)e(t-1) + \Theta(2)e(t-2) + ...$$
$$= \sum_{i=0}^{\infty} \Theta(i)e(t-i)$$

with Var(e)=I, and where $\Theta(i) = \Phi(i)P$, for i=0,1,2...; e(t)=P^{-1}u(t), and the matrix P has to satisfy Ω= PP'. [5]

Since we are interested in the impulse response of the system (particularly in productivity response to demand-induced innovations in aggregate activity), the identification of such disturbances is a crucial issue. By following Sbordone (1992), we achieve identification by imposing a Wold-causal chain on ΔY and Δs_i, through the lower Cholesky decomposition of the residual covariance matrix Ω. That is, we assume that the growth of aggregate output affects contemporaneously sectoral productivity growth, but not viceversa. As emphasized in the introduction, this is a plausible assumption, given the limited size of each sector (either four-digit or two-digit level, depending on the data) vis-à-vis the whole manufacturing sector.

Clearly, this identification is equivalent, within the framework of structural Vector Autoregressive models, to a short-run restriction –i.e., constraining sectoral disturbances to have no contemporaneous effect on aggregate activity growth.

We estimate the model by pooling the 402 four-digit industries in several ways (see next section). In either case, the omission of individual industry effects would result in biased and inconsistent within-group estimates of the parameters. To this regard, at least two alternative estimating procedures are available. If the number of observations is large enough, one can treat individual effects as constants to be estimated, and use the familiar dummy variables least squares estimator, or within-estimator (see for example Hsiao, 1986). The other procedure –which is necessary when the number of observations is small, and the within-estimator is therefore inconsistent– consists of differencing the original

[5]Notice that the disturbances e(t) are mutually uncorrelated by construction. See for example Luetkepohl (1991). Note also that P is not uniquely defined, up to this point.

equation, thus eliminating any (constant) individual effects. One can then use instrumental variables to estimate the parameters of the transformed equation. The use of instruments is necessary because of the induced serial correlation in the error term and the presence of lagged dependent variables. Such estimating strategy has been first applied to a Vector Autoregressive model by Holtz-Eakin et al. (1988). However, since our original data are first differences (rates of growth), if we differenced them we would be dealing with second differences, thus possibly facing all sorts of problems induced by overdifferencing. On the other hand, we do have as many as thirty-two observations –quite a large number for panel data. We therefore use throughout the paper the dummy variables least squares estimator. [6]

Before discussing our results, it is worth pointing out the direction of our investigation. Due to adjustment costs and effort variations, cycles do affect contemporaneously measured productivity growth –i.e., the Solow residual– regardless of the presence of thick-market effects and the like (see for example Morrison, 1988). It is almost impossible, therefore, to disentangle the former effects within a static analysis. A dynamic analysis, on the other hand, can offer some insights, as follows.

Let us consider effort variations. After a temporary shock to ΔY –which corresponds to a permanent increase of the level of Y– in the presence of adjustment costs, effort is likely to increase in the short-run, in order to accomodate the increased demand. This would show up as an (apparent) increase of the Solow residual. In the medium-run, however, effort would decrease and labor force (and capital) would adjust to the new production levels. If this is indeed the case, the decrease of effort would result in a negative Solow residual, during one or more periods after the initial shock (unless effort variation effects are more than offset by "true" external effects).

Consider now thick market effects and other "productive" externalities. If they take place, a permanent increase of aggregate activity

[6]In any case, we also estimated the model with instrumental variables and second differences. The results are very similar to the ones obtained with the dummy variables least square estimator, and for some sectors more favourable to our hypothesis.

should have a persistent positive effect on productivity level. On the other hand, such persistent effect –if any– could not be attributed to labor hoarding effects, since effort variations clearly cancel out in the medium run. Therefore, we interpret the persistence of productivity level above its starting value –after a permanent increase of aggregate activity– as evidence of thick market effects and the like. In the next section, we offer informal evidence on the matter, and also use a Bonferroni testing procedure.

3 Data

Most of the data that we use in this paper were obtained from a large data set developed by Wayne Gray at NBER, which covers 450 U.S. 4-digit SIC level manufacturing industries, in the period 1958-84. The main source of such data set is the Annual Survey of Manufacturers, conducted by the U.S. Census Bureau. Gross output is value of shipments plus inventory change. Intermediate inputs include both materials and energy, although they exclude purchased services, therefore resulting in a slight underestimation of total intermediate inputs. Data on capital refer to both structures and equipment. They are based on estimates from a joint project by the University of Pennsylvania, the Census Bureau and SRI Inc., and from the Bureau of Industrial Economics of the Commerce Department. For detailed documentation on the data set, see Gray (1989).

As mentioned above in the paper, the detail of our dataset allows us to compute sectoral Solow residual by using data on two different labor inputs –i.e., production workers hours, and the number of non-production workers (unfortunately, we do not have data on non-production worker hours). However, Gray's data on compensation of labor inputs do not include Social Security benefits and the pay of employees in auxiliary units, who account for as much as 10 per cent of total employees. That is, they underestimate true labor compensation. Therefore, if we used the original Gray's data (as Bartelsman et al., 1994, do) we would underestimate the labor elasticity of output in the computation of Solow residual, thus introducing a potential bias in our results (see Norrbin, 1993, on such problem with regard to the estimation of markups). In order to avoid that, we adjust Gray's four-digit labor compensation data by using two-digit figures from U.S. National Income and Production Accounts (NIPA)[7], and assuming that labor compensation data of four-digit industries within each two-digit sector are uniformly underestimated.

4 Empirical Results

We first estimated our model by pooling the four-digit industries (i) all together, and (ii) in two groups, respectively durable and nondurable goods industries. To take into account individual fixed-effects at four-digit level, we used the familiar dummy variables least squares estimator, with two dummies for each industry: one for the pre-1973 period and one for post-1973. By doing so we try to capture the possible change of trend of variables after the oil crisis. [8]

For the purposes of our analysis, we focus on the response of productivity level (i.e., cumulated Solow residuals) to aggregate shocks. [9] The impulse responses are shown –for the three models with, respectively, (i) durable goods industries, (ii) nondurable goods industries and (iii) all industries– in Figures B.1 to B.3, at the end of the paper. As usual, the graphs trace the response of each variable to a unit (one standard error) orthogonal shock. All responses are measured as percent changes with respect to the equilibrium path. One standard error bands surround the point estimates of the responses. [10]

By examining them, the following robust results emerge clearly. First, aggregate shocks do have a large contemporaneous positive effect

[7]Kindly provided by Robert Hall.

[8]See Perron (1989).

[9]We calculate the response of the Solow Residual (i.e., productivity growth) to aggregate shocks and then cumulate these increases to a given initial level, in order to obtain the response of productivity level.

[10]Standard errors are computed from the asymptotic distribution of the response estimates, as suggested in Luetkepohl (1991).

on productivity. In the pooled model, for example, productivity increases in the same period by 2 percent in response to a unit standard error aggregate shock (of the approximate size of 6 percent). Therefore, theories which try to explain such effect (such as those based on adjustment costs and labor hoarding or productive externalities) are worth pursuing. In other words, there seems to be a not insignificant portion of the interaction between the business cycle and productivity which is not captured by pure real business cycle theories.

Second, for the pooled model and the non durables model productivity typically decreases during one or more periods after an aggregate shock, after the initial surge. As mentioned above, we interpret such result as evidence of effort variations. This sheds some light, therefore, on some of the factors which possibly underlie the positive contemporaneous effect of aggregate activity on productivity, mentioned above. For the durables model, however, the level of productivity remains virtually unchanged after the initial increase. This suggests that either labor hoarding effects are not very important in these sectors, or, more likely, that the impact of effort variation on measured productivity is offset by that of "true" externalities.

Third, and perhaps more importantly, as time passes –after a permanent increase of aggregate activity– productivity level does not return to its original level, but rather converge to a new, higher equilibrium level. In other words, there appears to be a persistent positive effect of aggregate activity on productivity. This result is much clearer for durables than for non durables, although for both cases the t-test strongly rejects the null hypothesis. The estimates of the long run responses of productivity level are reported in Table 4.1, together with the impact responses, for each model.

In order to achieve further evidence on the matter, we estimated the model separately for each two-digit sector, by pooling four-digit industries within each of them. That is, we exploited the cross-section dimension of our sample to estimate separate VAR models for each two-digit industry. The fairly reasonable homogeneity among the cross-section units involved in such regressions would yield quite accurate estimates.

Table 1: **Response of productivity level to aggregate shocks (percent)**

	First Period		Long Run	
	Response	S.E.	Response	S.E.
Pooled model	2.06	0.06	1.88	0.09
Durable Goods	2.41	0.07	2.42	0.11
Nondurable Goods	1.47	0.10	0.97	0.15

Note: Annual data for 4-digit SIC manufacturing industries. The coefficients of the VAR(1) are estimated using two dummies for each industry (pre and post-1973). The standard errors of the impulse responses are estimated following Luetkepohl (1991).

The estimates of both first-period and long-run responses of productivity level to aggregate shocks are reported, for each two-digit sector, in Table 4.2. The complete graph of such response is reported in Figures B.7 to B.11, at the end of the paper. It is worth pointing out that the new findings –although they vary widely across sectors– confirm all the main results observed with the more aggregate models. Also, at first sight, durable good industries tend to show a larger long-run response of productivity level to aggregate shocks than nondurable goods industries.

More formally, the significance of the long-run response of productivity can be assessed separately for each industry. We would reject the null hypothesis (zero long-run response) in 12 industries out of 19, at 5% one-tail significance level. However, by doing so, the overall probability of rejecting a true null hypothesis increases with the number of industries, and is significantly higher than the significance level for each industry. To avoid that, we use the sequential Bonferroni approach suggested by Holm (1979), and test the null hypothesis for each industry with an *overall* significance level α of 5%. That is, we consider the industry with the highest t-statistics –i.e., industry 35 (Machinery)– and set the significance level equal to α/n, where n is the number of industries. Notice that $\alpha/n = 0.0025$, which is significantly smaller than the original 0.05. Since the one-tail p-value corresponding to 15.6 (the t value

Table 2: **Response of productivity level to aggregate shocks (percent)**

Industry	First Period		Long Run	
	Response	S.E.	Response	S.E.
21. Tobacco	0.92	0.60	1.03	0.87
22. Textile mill	1.08	0.24	0.02	0.35
23. Apparel	0.95	0.22	0.39	0.30
24. Lumber-Wood	0.30	0.29	-1.36	0.38
25. Furniture	2.51	0.28	1.85*	0.41
26. Paper	1.67	0.23	1.09*	0.33
27. Printing	1.60	0.24	1.45*	0.34
28. Chemicals	2.91	0.26	2.89*	0.41
29. Petroleum-Coal	1.09	0.57	0.89	0.98
30. Ribber-Plastic	2.38	0.40	2.35*	0.55
31. Leather	-0.19	0.39	-0.96	0.54
32. Stone-Clay-Glass	2.28	0.20	1.98*	0.29
33. Primary Metals	2.63	0.28	2.36*	0.38
34. Fabr. Metals	2.66	0.18	2.47*	0.27
35. Machinery	2.96	0.17	4.36*	0.26
36. Electric Mach.	3.10	0.18	3.13*	0.30
37. Transport. Equipment	1.57	0.27	1.31*	0.40
38. Instruments	1.80	0.28	2.53*	0.40
39. Miscellaneous	2.29	0.31	1.57*	0.43

Note: Annual data for 4-digit SIC manufacturing industries. The coefficients of the VAR(1) are estimated using two dummies for each industry (pre and post-1973). The standard errors of the impulse responses are estimated following Luetkepohl (1991). The starred long run responses are those significant at 5 percent level according to the Bonferroni sequential procedure described in the text.

Table 3: **Response of productivity level to aggregate shocks with Jorgenson's two-digit data (percent)**

	First Period		Long Run	
	Response	S.E.	Response	S.E.
Pooled model	0.85	0.11	0.44	0.20
Durable Goods	1.11	0.15	0.67	0.31
Nondurable Goods	0.55	0.15	0.16	0.24

Note: Annual data for 2-digit SIC manufacturing industries. The coefficients of the VAR(1) are estimated using two dummies for each industry (pre and post-1973). The standard errors of the impulse responses are estimated following Luetkepohl (1991).

of Machinery) is lower than 0.0025, we reject the null hypothesis with regard to industry 35. The sequential Bonferroni procedure requires that we examine the industry with the second-highest t-statistic, set the significance level equal to $\alpha/(n\text{-}1)$, perform the test, and so on, until we are unable to reject the null hypothesis. Such procedure allows to perform each test in concordance with the desired overall significance level. In our case, the procedure stopped at its 13th step, since we were unable to reject the null hypothesis for the 13th industry considered, i.e. Tobacco. Sectors with significative long run response are 12 out of 19, and are starred in the Table. They are mainly durable goods industries, [11] consistently with the results obtained with the pooled models.

To test whether our results are affected by the aggregation level or any other feature of the data, we estimated the model using Jorgenson et al.'s (1987) data on two-digit industries. Again, we estimated three different models, by pooling respectively all industries, durable goods industries, and nondurable goods industries. The first-period and long-run response of productivity level to aggregate shocks are reported in Table 3.3, for each model. The graphs of the impulse responses can be found in Appendix B, Figures B.4–B.6.

[11]Durable goods industries are those with SIC code 24, 25 and 32 through 39.

The evidence available from this dataset largely confirms our main results. In fact, aggregate shocks have a significant contemporaneous positive effect on productivity growth, increasing the level of productivity. In subsequent periods, the response of productivity growth is negative, but smaller than the initial effect, thus leaving the level of productivity above its initial value. Furthermore, and more interestingly, the long run response of productivity level is positive in all three models –although lower than that obtained with four-digit data– and statistically different from zero in both the pooled model and durable goods industries.

A further comment on our findings. They are quite different from those obtained by Gali and Hammour (1993) and Saint Paul (1993). They find that the long-run response of productivity level to demand shocks is negative. Our findings are that it is either positive or positively close to zero, depending on the industry. A first reason behind the different results may lie in the aggregation level of the data used, since Gali and Hammour and Saint Paul use economy-wide data, and the aggregation levels of ΔY and Δs are the same in their model. However, we believe that the main source of difference is rather related to their identification approach, which assumes away any thick-market effects, and, more importantly, requires the use of effort-adjusted productivity measures. The problems involved in such adjustments can be considerable. However, we do not mean to deny the role played during recessions by productivity-improving activities, as those described by Gali and Hammour and Saint Paul. Nor we dismiss the cleansing effects of slumps on techniques and enterprises, emphasized long ago by Schumpeter (1939). Rather, we interpret our results –along the lines of Gali and Hammour's theoretical model– as suggesting that the positive effects of expansions on productivity more than offset the negative ones.

Finally, one might suspect that our results are simply due to aggregate supply shocks, such as the 1973 and 1978 oil price shocks. This would also explain the difference between our results and those just mentioned. To clarify this point, we estimated an extended version of our VAR model, with three variables –the rate of growth of oil price, the rate of growth of aggregate manufacturing output, and sectoral Solow residual. We achieved identification by imposing a Wold causal chain on the variables. With such model, we disentangle oil price disturbances, and therefore can interpret aggregate shocks to manufacturing output as mainly demand shocks. Both first-period and long-run responses of productivity level to such aggregate disturbances are reported in Table A.1, at the end of the paper, for the three pooled models, and in Table A.3 for each two-digit industry. As it can be seen, the effect of aggregate activity on productivity has not diminished overall, and the long run response is significantly different from zero in 8 out of 19 industries (starred in the table) at the 5 percent overall significance level, according to the sequential Bonferroni procedure. Finally, we also estimated the extended model with Jorgenson data. Although the estimates of the response of productivity to aggregate shocks are smaller than those obtained with 4-digit data, one cannot reject the hypothesis of a positive long-run effect.

5 Conclusions

There has been recently a number of papers –both theoretical and – which have explored the existence of externalities which would make the output of one firm, or one industry, complementary to the output of other firms or industries, or the aggregate economic activity, at business cycle frequencies. Most of such spillovers are usually assumed to be on the demand side, as in the models by Kiyotaki (1988) and Murphy et al. (1989). However, some economists such as Hall (1990 and 1991) have emphasized the role of productive externalities, like the trading effects described by Diamond (1982). Supply-side externalities have indeed been suggested by Hall and others as one main source of procyclical productivity, and some evidence on the matter has been provided by Bartelsman et al. (1994).

In this paper, we have investigated the dynamic effect of aggregate activity on sectoral productivity. By building upon Sbordone's (1992) work, we have fitted a Vector Autoregressive model to a highly disaggregate panel data set of 402 four-digit U.S. manufacturing industries. To disentangle effort variation effects from "true" externalities, if any, we have simulated a demand-induced permanent increase of aggregate activity, and analyzed the response of productivity level over time. We find evidence of effort variation effects. Furthermore, and more interestingly, our results support the existence of thick-market effects and other productive externalities, and therefore point to them as a potential source of social increasing returns and multiple equilibria. Finally, unlike recent papers by Gali and Hammour (1993) and Saint-Paul (1993), we find no evidence of long-run negative effects of expansions on productivity. Corroborative evidence is provided using Jorgenson's two-digit data.

References

[1] Abbott, T., Z. Griliches and J. Hausman (1989). "Short-run movements in productivity: Market power vs. capacity utilization." Manuscript.

[2] Aghion, P. and G. Saint-Paul (1991). "On the Virtues of Bad Times." CEPR Working Paper no. 578 (CEPR, London).

[3] Bartelsman, E., R. Caballero and R. Lyons (1994). "Customer and Supplier-Driven Externalities." American Economic Review 84: 1075-84.

[4] Basu, S. and J.G. Fernald, (1993). "Are Apparent Productive Spillovers a Figment of Specification Error?" International Finance Discussion Paper no. 463. Board of Governors of the Federal Reserve System.

[5] Bean, C. (1990). "Endogenous Growth and the Procyclical Behaviour of Productivity." European Economic Review 34: 355-363.

[6] Bernanke, B. (1986). "Alternative Explanations of the Money-Income Correlation." Carnegie-Rochester Conference Series of Public Policy 25: 49-100.

[7] Bernanke, B.S. and M.L. Parkinson (1991). "Procyclical Labor Productivity and Competing Theories of the Business Cycle: Some Evidence from Interwar U.S. Manufacturing Industries." Journal of Political Economy 99: 439-459.

[8] Blanchard, O. and D. Quah (1989). "The Dynamic Effects of Aggregate Demand and Supply Disturbances." American Economic Review 79: 655-673.

[9] Caballero, R.J. and M.L. Hammour (1991). "The Cleansing Effect of Recessions." NBER Working Paper no. 3922.

[10] Caballero, R.J. and R.K. Lyons (1992). "External Effects in U.S. Procyclical Productivity." Journal of Monetary Economics 29: 209-25.

[11] Canova, F. (1992). "Vector Autoregressive Models: Specification, Estimation, Inference and Forecasting." Manuscript.

[12] Diamond, P. (1982). "Aggregate Demand Management in Search Equilibrium." Journal of Political Economy 90: 881-894.

[13] Domowitz, I., R.G. Hubbard and B.C. Petersen (1988). "Market Structure and Cyclical Fluctuations in U.S. Manufacturing." Review of Economics and Statistics 70: 55-66.

[14] Durlauf, S.N. (1991). "Multiple Equilibria and Persistence in Aggregate Fluctuations." NBER Working Paper no.

[15] Gali, J. (1992). "How Does the IS-LM Model Fit Postwar U.S. Data?" Quarterly Journal of Economics 107: 709-38.

[16] Gali, J. and M.L. Hammour (1993). "Long Run Effects of Business Cycles." Manuscript.

[17] Gordon, R. (1990). "Are Procyclical Productivity Fluctuations a Figment of Measurement Errors?" Northwestern University, Manuscript.

[18] Gray, W.B. (1989). "Productivity Database." Clark University, Manuscript.

[19] Hall, R.E. (1988). "The Relation between Price and Marginal Cost in U.S. Industry." Journal of Political Economy 96: 921-47.

[20] Hall, R.E. (1990). "Invariance Properties of Solow's Productivity Residual." In P. Diamond, ed., Growth, Productivity, Employment (MIT Press, Cambridge, Mass.): 71-112.

[21] Hall, R.E. (1991). "Labor Demand, Labor Supply and Employment Volatility." NBER Macroeconomics Annual 6: 17-47.

[22] Hsiao, C. (1986). Analysis of Panel Data, Cambridge, UK: Cambridge University Press.

[23] Holm, S. (1979). "A Simple Sequentially Rejective Multiple Test Procedure." Scandinavian Journal of Statistics 6: 65-70.

[24] Holtz-Eakin, D., W. Newey and H.S. Rosen (1988). "Estimating Vector Autoregressions with Panel Data." Econometrica 56: 1047-1070.

[25] Jorgenson, D.W., F.M. Gollop and B.M. Fraumeni (1987). Productivity and U.S. Economic growth, Cambridge: MIT Press.

[26] Kydland, F. and E. Prescott (1982). "Time to Build and Aggregate Fluctuations." Econometrica 50: 1345-1370.

[27] Kiyotaki, N. (1988). "Multiple Expectional Equilibria Under Monopolistic Competition." Quarterly Journal of Economics 103: 695-714.

[28] Long, J. and Plosser C. (1982). "Real Business Cycles." Journal of Political Economy 91: 39-69.

[29] Luetkepohl, H. (1991). Introduction to Multiple Time Series Analysis, Berlin: Springer-Verlag.

[30] Marchetti, D. (1994). "Procyclical Productivity, Extrenalities and Labor Hoarding: A Reexamination of Evidence from U.S. Manufacturing." European University Institute Working Paper in Economics no. 13/94 (EUI, Florence).

[31] Murphy, K.M., A. Schleifer and R.W. Vishny (1989). "Industrialization and the Big Push." Journal of Political Economy 97: 1003-26.

[32] Norbbin, S.C. (1993). "The Relation between Price and Marginal Cost in U.S. Industry: A Contradiction." Journal of Political Economy 101: 1149-1164.

[33] Perron (1989). "The great crash, the oil price shock, and the unit root hypothesis." Econometrica 57: 1361-1401.

[34] Prescott, E.C. (1986). "Theory Ahead of Business Cycle Measurement." Federal Reserve Bank of Minneapolis Quarterly Review 10: 9-22.

[35] Rosenberg, N. (1982). Inside the Black Box: Technology and Economics, New York: Cambridge University Press.

[36] Rotemberg, J. and L. Summers (1990). "Inflexible Prices and Procyclical Productivity." Quarterly Journal of Economics 105: 851-74.

[37] Saint-Paul, G. (1993). "Productivity Growth and the Structure of the Business Cycle." European Economic Review 37: 861-890.

[38] Sbordone, A. (1992). "Procyclical Productivity: External or Labor Hoarding?" University of Chicago, Manuscript.

[39] Schumpeter, J.A. (1939). Business Cycles, New York: McGraw-Hill.

[40] Shea, J. (1992). "Accident Rates, Labor Effort and the Business Cycle." University of Wisconsin, Madison, Manuscript.

[41] Solow, R.M. (1956). "A Contribution to the Theory of Economic Growth." American Economic Review

[42] Stockman, A.C. (1988). "Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries." Journal of Monetary Economics 21: 387-409.

[43] Weitzman, M.L. (1982). "Increasing Returns and the Foundations of Unemployment Theory." The Economic Journal 92: 787-804.

A Results for the 3-variable VAR model: Oil price changes, aggregate activity changes and sectoral Solow Residuals

Table 4: **Response of productivity level to aggregate shocks in the 3-variables VAR**

	First Period		Long Run	
	Response	S.E.	Response	S.E.
Pooled model	2.05	0.06	1.95	0.09
Durable Goods	2.46	0.07	2.48	0.11
Nondurable Goods	1.38	0.10	1.06	0.15

Note: Annual data for 4-digit SIC manufacturing industries. The coefficients of the VAR(1) are estimated using two dummies for each industry (pre and post-1973). The standard errors of the impulse responses are estimated following Luetkepohl (1991). The other responses of the VAR are omitted here.

Table 5: **Response of productivity level to aggregate shocks in the 3-variable VAR with Jorgenson's data**

	First Period		Long Run	
	Response	S.E.	Response	S.E.
Pooled model	0.44	0.10	0.08	0.15
Durable Goods	0.57	0.15	0.09	0.23
Nondurable Goods	0.30	0.15	0.03	0.18

Note: Annual data for 2-digit SIC manufacturing industries. The coefficients of the VAR(1) are estimated using two dummies for each industry (pre and post-1973). The standard errors of the impulse responses are estimated following Luetkepohl (1991). The other responses of the VAR are omitted here.

Table 6: **Response of productivity level to aggregate shocks in the 3-variables VAR**

Industry	First Period		Long Run	
	Response	S.E.	Response	S.E.
21. Tobacco	0.21	0.58	-0.19	0.63
22. Textile mill	0.77	0.24	0.11	0.27
23. Apparel	0.78	0.22	0.33	0.23
24. Lumber-Wood	-0.08	0.29	-0.88	0.29
25. Furniture	1.81	0.27	0.94*	0.30
26. Paper	0.81	0.23	0.11	0.24
27. Printing	1.34	0.23	0.93*	0.26
28. Chemicals	1.54	0.25	0.62	0.29
29. Petroleum-Coal	0.88	0.57	0.67	0.73
30. Ribber-Plastic	1.63	0.39	0.89	0.41
31. Leather	0.02	0.39	-0.25	0.40
32. Stone-Clay-Glass	1.22	0.19	0.45	0.21
33. Primary Metals	1.71	0.27	0.91*	0.27
34. Fabr. Metals	1.52	0.17	0.68*	0.19
35. Machinery	2.15	0.16	1.96*	0.18
36. Electric Mach.	1.87	0.17	1.00*	0.20
37. Transport. Equipment	0.89	0.26	0.34	0.30
38. Instruments	1.52	0.28	1.36*	0.28
39. Miscellaneous	1.71	0.31	0.95*	0.32

B Graphics of the impulse-responses of productivity level to a one standard-error shock in aggregate activity growth (percent)

Figure 1: **Durables. Pooled 4-Digit Industries.**

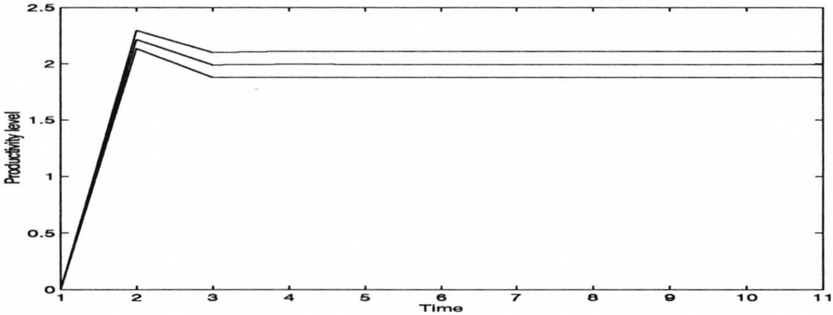


Figure 2: **Non-Durables. Pooled 4-Digit Industries.**

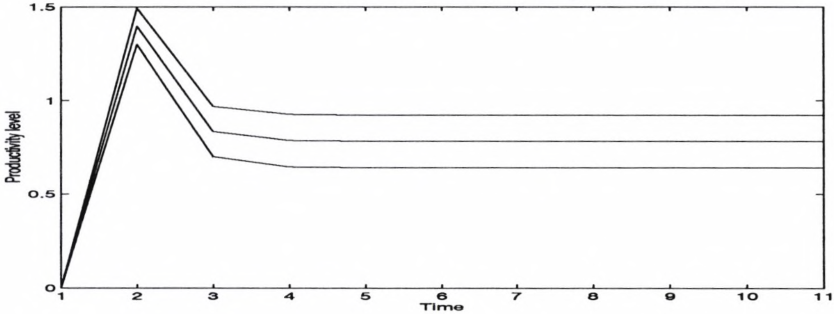


Figure 3: **All Industries. Pooled 4-Digit Industries.**

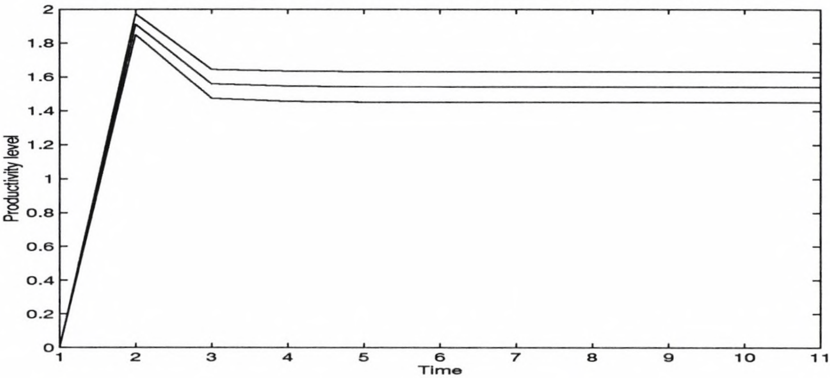


Figure 4: **Jorgenson Data. Durables. Pooled 2-Digit Industries.**

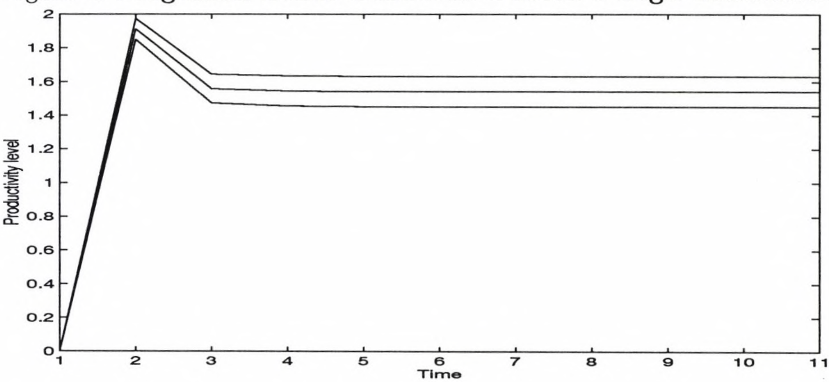


Figure 5: **Jorgenson Data. Non-Durables. Pooled 2-Digit Industries.**

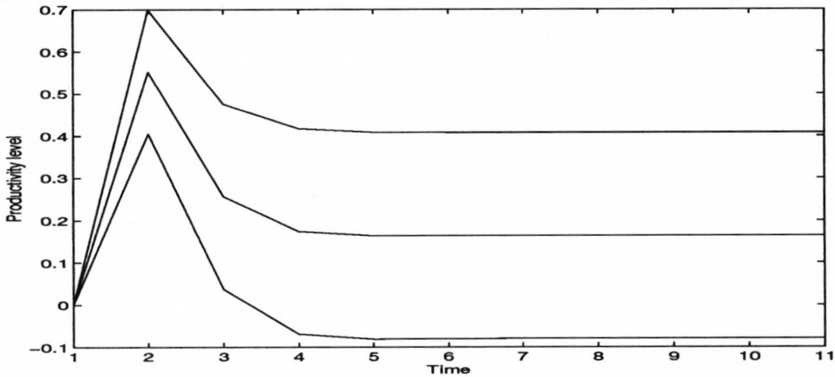


Figure 6: **Jorgenson Data. All Sectors. Pooled 4-Digit Industries.**

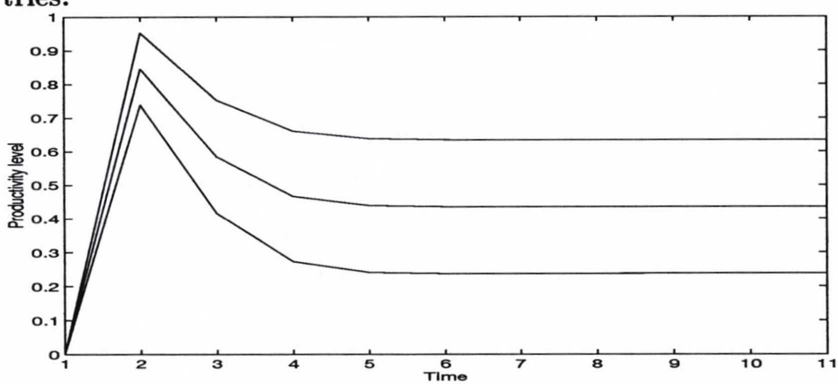


Figure 7: **4-Digit Industries Pooled within 2-Digit Sectors: 21–24.**

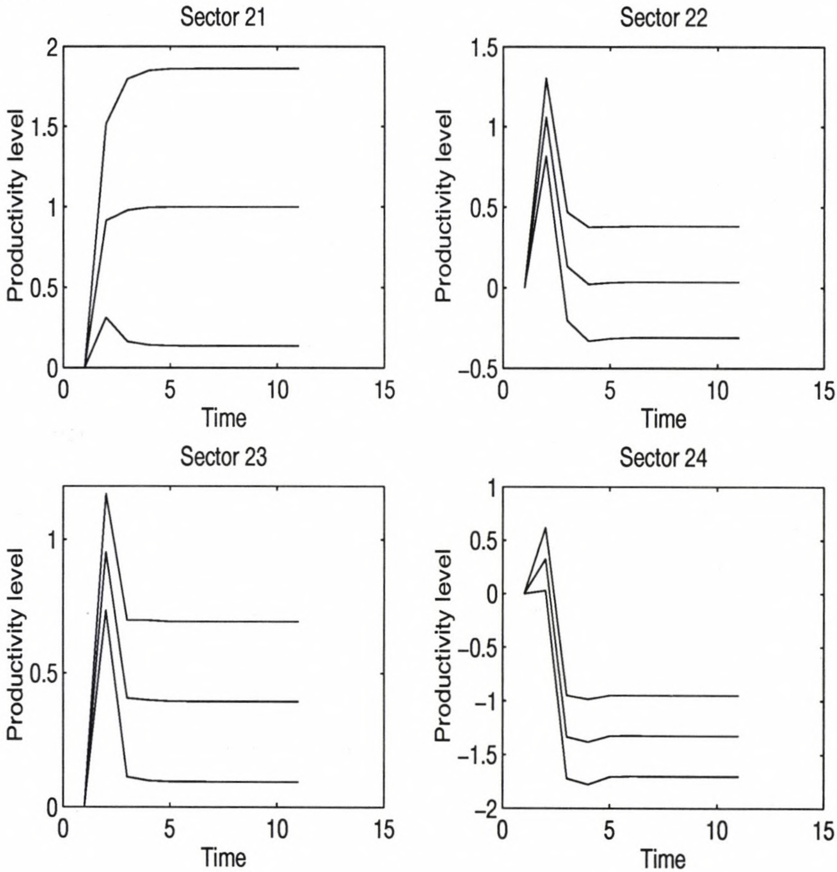


Figure 8: **4-Digit Industries Pooled within 2-Digit Sectors: 25–28.**

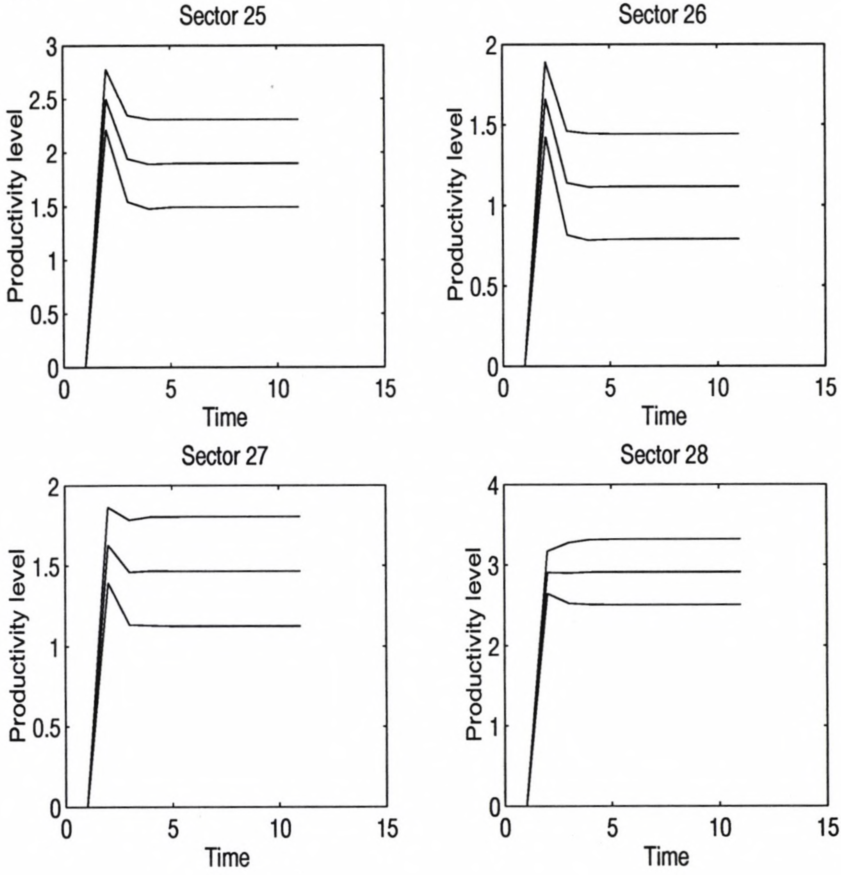


Figure 9: **4-Digit Industries Pooled within 2-Digit Sectors: 29–32.**

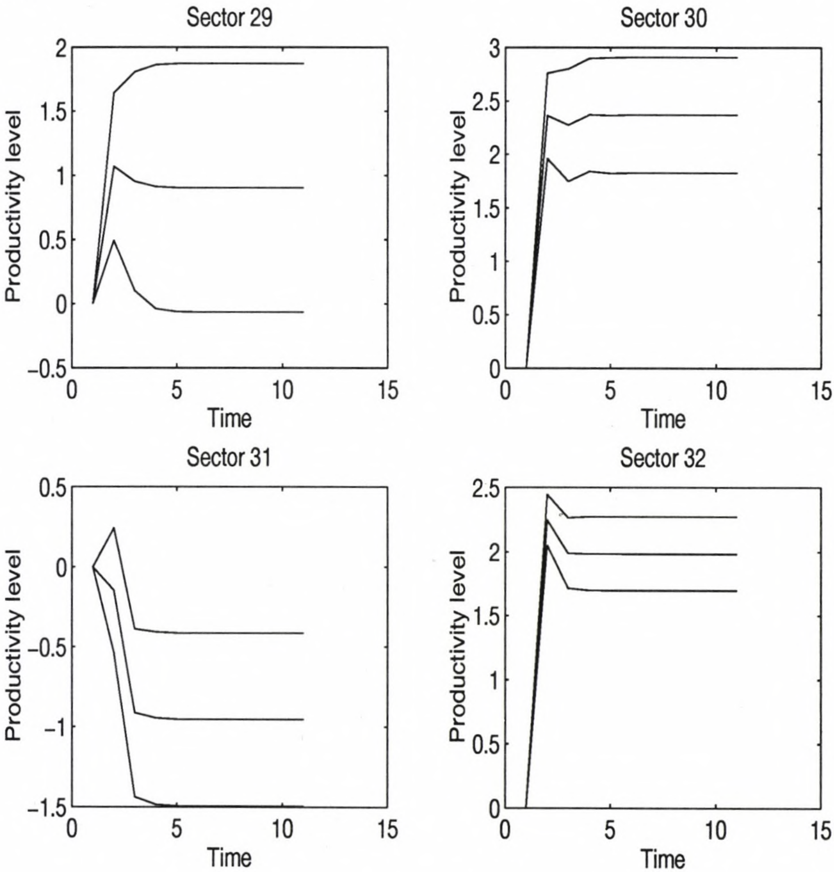


Figure 10: **4-Digit Industries Pooled within 2-Digit Sectors: 33–36.**

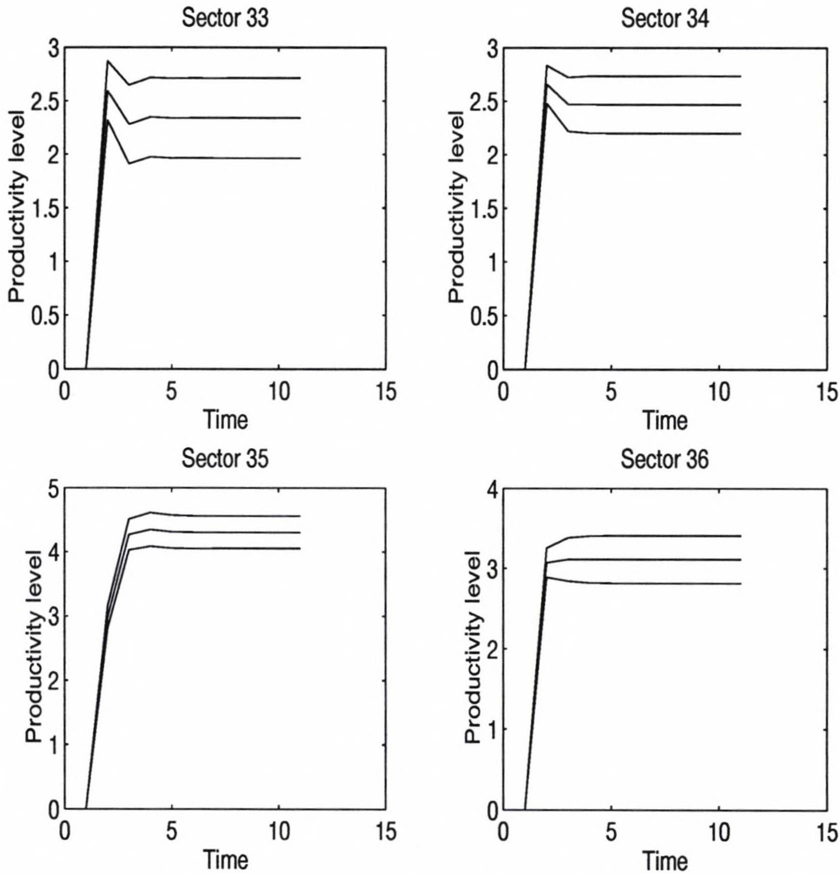
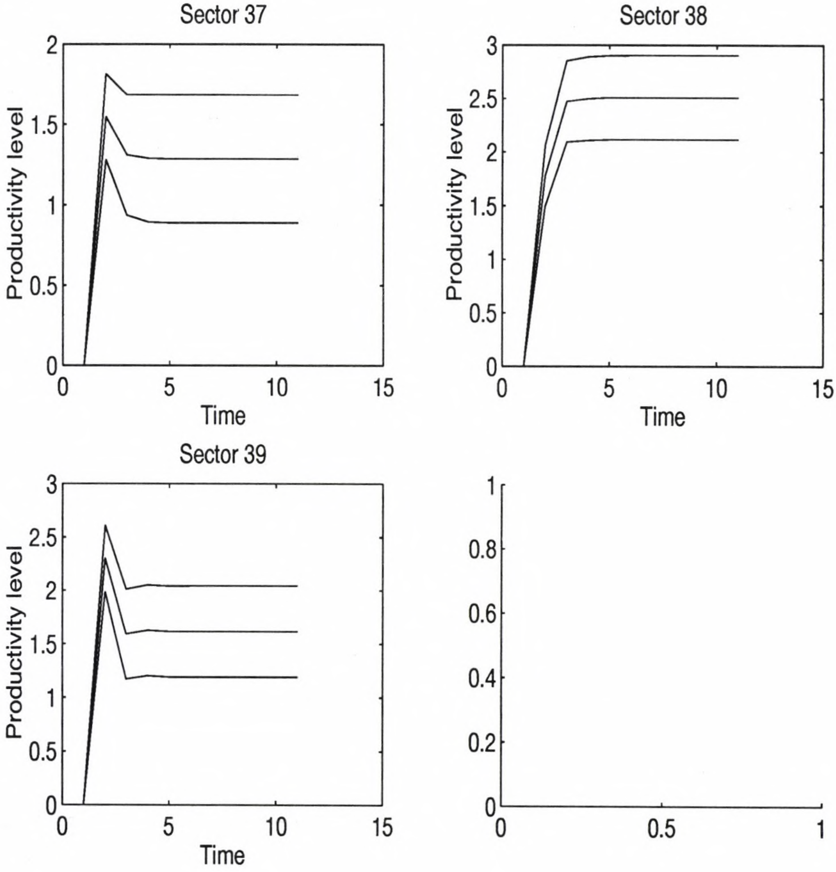


Figure 11: **4-Digit Industries Pooled within 2-Digit Sectors: 37–39.**



EUI WORKING PAPERS

EUI Working Papers are published and distributed by the
European University Institute, Florence

Copies can be obtained free of charge
– depending on the availability of stocks – from:

The Publications Officer
European University Institute
Badia Fiesolana
I-50016 San Domenico di Fiesole (FI)
Italy

Please use order form overleaf

Publications of the European University Institute

Department of Economics Working Paper Series

To Department of Economics **WP**
European University Institute
Badia Fiesolana
I-50016 San Domenico di Fiesole (FI)
E-mail: publish@datacomm.iue.it
Italy

From Name . . . .

Address. . . . .

. . . .

. . . .

. . . .

. . . .

(Please print)

❐ Please enter/confirm my name on EUI Economics Dept. Mailing List
❐ Please send me a complete list of EUI Working Papers
❐ Please send me a complete list of EUI book publications
❐ Please send me the EUI brochure Academic Year 1995/96

Please send me the following EUI **ECO** Working Paper(s):

No, Author . . . .
Title: . . . .
No, Author . . . .
Title: . . . .
No, Author . . . .
Title: . . . .
No, Author . . . .
Title: . . . .

Date . . . . Signature . . . .

Working Papers of the Department of Economics Published since 1993

ECO No. 93/1
Carlo GRILLENZONI
Forecasting Unstable and Non-Stationary Time Series

ECO No. 93/2
Carlo GRILLENZONI
Multilinear Models for Nonlinear Time Series

ECO No. 93/3
Ronald M. HARSTAD/Louis PHLIPS
Futures Market Contracting When You Don't Know Who the Optimists Are

ECO No. 93/4
Alan KIRMAN/Louis PHLIPS
Empirical Studies of Product Markets

ECO No. 93/5
Grayham E. MIZON
Empirical Analysis of Time Series: Illustrations with Simulated Data

ECO No. 93/6
Tilman EHRBECK
Optimally Combining Individual Forecasts From Panel Data

ECO NO. 93/7
Víctor GÓMEZ/Agustín MARAVALL
Initializing the Kalman Filter with Incompletely Specified Initial Conditions

ECO No. 93/8
Frederic PALOMINO
Informed Speculation: Small Markets Against Large Markets

ECO NO. 93/9
Stephen MARTIN
Beyond Prices Versus Quantities

ECO No. 93/10
José María LABEAGA/Angel LÓPEZ
A Flexible Demand System and VAT Simulations from Spanish Microdata

ECO No. 93/11
Maozu LU/Grayham E. MIZON
The Encompassing Principle and Specification Tests

ECO No. 93/12
Louis PHLIPS/Peter MØLLGAARD
Oil Stocks as a Squeeze Preventing Mechanism: Is Self-Regulation Possible?

ECO No. 93/13
Pieter HASEKAMP
Disinflation Policy and Credibility: The Role of Conventions

ECO No. 93/14
Louis PHLIPS
Price Leadership and Conscious Parallelism: A Survey

ECO No. 93/15
Agustín MARAVALL
Short-Term Analysis of Macroeconomic Time Series *

ECO No. 93/16
Philip Hans FRANSES/Niels HALDRUP
The Effects of Additive Outliers on Tests for Unit Roots and Cointegration

ECO No. 93/17
Fabio CANOVA/Jane MARRINAN
Predicting Excess Returns in Financial Markets

ECO No. 93/18
Iñigo HERGUERA
Exchange Rate Fluctuations, Market Structure and the Pass-through Relationship

ECO No. 93/19
Agustín MARAVALL
Use and Misuse of Unobserved Components in Economic Forecasting

ECO No. 93/20
Torben HOLVAD/Jens Leth HOUGAARD
Measuring Technical Input Efficiency for Similar Production Units:
A Survey of the Non-Parametric Approach

*out of print

ECO No. 93/21
Stephen MARTIN/Louis PHLIPS
Product Differentiation, Market Structure and Exchange Rate Passthrough

ECO No 93/22
F. CANOVA/M. FINN/A. R. PAGAN
Evaluating a Real Business Cycle Model

ECO No 93/23
Fabio CANOVA
Statistical Inference in Calibrated Models

ECO No 93/24
Gilles TEYSSIÈRE
Matching Processes in the Labour Market in Marseilles. An Econometric Study

ECO No 93/25
Fabio CANOVA
Sources and Propagation of International Business Cycles: Common Shocks or Transmission?

ECO No. 93/26
Marco BECHT/Carlos RAMÍREZ
Financial Capitalism in Pre-World War I Germany: The Role of the Universal Banks in the Financing of German Mining Companies 1906-1912

ECO No. 93/27
Isabelle MARET
Two Parametric Models of Demand, Structure of Market Demand from Heterogeneity

ECO No. 93/28
Stephen MARTIN
Vertical Product Differentiation, Intra-industry Trade, and Infant Industry Protection

ECO No. 93/29
J. Humberto LOPEZ
Testing for Unit Roots with the k-th Autocorrelation Coefficient

ECO No. 93/30
Paola VALBONESI
Modelling Interactions Between State and Private Sector in a "Previously" Centrally Planned Economy

ECO No. 93/31
Enrique ALBEROLA ILA/J. Humberto LOPEZ/Vicente ORTS RIOS
An Application of the Kalman Filter to the Spanish Experience in a Target Zone (1989-92)

ECO No. 93/32
Fabio CANOVA/Morten O. RAVN
International Consumption Risk Sharing

ECO No. 93/33
Morten Overgaard RAVN
International Business Cycles: How much can Standard Theory Account for?

ECO No. 93/34
Agustín MARAVALL
Unobserved Components in Economic Time Series *

ECO No. 93/35
Sheila MARNIE/John MICKLEWRIGHT
Poverty in Pre-Reform Uzbekistan: What do Official Data Really Reveal? *

ECO No. 93/36
Torben HOLVAD/Jens Leth HOUGAARD
Measuring Technical Input Efficiency for Similar Production Units: 80 Danish Hospitals

ECO No. 93/37
Grayham E. MIZON
A Simple Message for Autocorrelation Correctors: DON'T

ECO No. 93/38
Barbara BOEHNLEIN
The Impact of Product Differentiation on Collusive Equilibria and Multimarket Contact

ECO No. 93/39
H. Peter MØLLGAARD
Bargaining and Efficiency in a Speculative Forward Market

***

*out of print

ECO No. 94/1
Robert WALDMANN
Cooperatives With Privately Optimal Price Indexed Debt Increase Membership When Demand Increases

ECO No. 94/2
Tilman EHRBECK/Robert WALDMANN
Can Forecasters' Motives Explain Rejection of the Rational Expectations Hypothesis?

ECO No. 94/3
Alessandra PELLONI
Public Policy in a Two Sector Model of Endogenous Growth *

ECO No. 94/4
David F. HENDRY
On the Interactions of Unit Roots and Exogeneity

ECO No. 94/5
Bernadette GOVAERTS/David F. HENDRY/Jean-François RICHARD
Encompassing in Stationary Linear Dynamic Models

ECO No. 94/6
Luigi ERMINI/Dongkoo CHANG
Testing the Joint Hypothesis of Rationality and Neutrality under Seasonal Cointegration: The Case of Korea

ECO No. 94/7
Gabriele FIORENTINI/Agustín MARAVALL
Unobserved Components in ARCH Models: An Application to Seasonal Adjustment *

ECO No. 94/8
Niels HALDRUP/Mark SALMON
Polynomially Cointegrated Systems and their Representations: A Synthesis

ECO No. 94/9
Mariusz TAMBORSKI
Currency Option Pricing with Stochastic Interest Rates and Transaction Costs: A Theoretical Model

ECO No. 94/10
Mariusz TAMBORSKI
Are Standard Deviations Implied in Currency Option Prices Good Predictors of Future Exchange Rate Volatility?

ECO No. 94/11
John MICKLEWRIGHT/Gyula NAGY
How Does the Hungarian Unemployment Insurance System Really Work? *

ECO No. 94/12
Frank CRITCHLEY/Paul MARRIOTT/Mark SALMON
An Elementary Account of Amari's Expected Geometry

ECO No. 94/13
Domenico Junior MARCHETTI
Procyclical Productivity, Externalities and Labor Hoarding: A Reexamination of Evidence from U.S. Manufacturing

ECO No. 94/14
Giovanni NERO
A Structural Model of Intra-European Airline Competition

ECO No. 94/15
Stephen MARTIN
Oligopoly Limit Pricing: Strategic Substitutes, Strategic Complements

ECO No. 94/16
Ed HOPKINS
Learning and Evolution in a Heterogeneous Population

ECO No. 94/17
Berthold HERRENDORF
Seigniorage, Optimal Taxation, and Time Consistency: A Review

ECO No. 94/18
Frederic PALOMINO
Noise Trading in Small Markets *

ECO No. 94/19
Alexander SCHRADER
Vertical Foreclosure, Tax Spinning and Oil Taxation in Oligopoly

ECO No. 94/20
Andrzej BANIAK/Louis PHLIPS
La Pléiade and Exchange Rate Pass-Through

ECO No. 94/21
Mark SALMON
Bounded Rationality and Learning; Procedural Learning

*out of print

ECO No. 94/22
Isabelle MARET
Heterogeneity and Dynamics of Temporary Equilibria: Short-Run Versus Long-Run Stability

ECO No. 94/23
Nikolaos GEORGANTZIS
Short-Run and Long-Run Cournot Equilibria in Multiproduct Industries

ECO No. 94/24
Alexander SCHRADER
Vertical Mergers and Market Foreclosure: Comment

ECO No. 94/25
Jeroen HINLOOPEN
Subsidising Cooperative and Non-Cooperative R&D in Duopoly with Spillovers

ECO No. 94/26
Debora DI GIOACCHINO
The Evolution of Cooperation: Robustness to Mistakes and Mutation

ECO No. 94/27
Kristina KOSTIAL
The Role of the Signal-Noise Ratio in Cointegrated Systems

ECO No. 94/28
Agustín MARAVALL/Víctor GÓMEZ
Program SEATS "Signal Extraction in ARIMA Time Series" - Instructions for the User

ECO No. 94/29
Luigi ERMINI
A Discrete-Time Consumption-CAP Model under Durability of Goods, Habit Formation and Temporal Aggregation

ECO No. 94/30
Debora DI GIOACCHINO
Learning to Drink Beer by Mistake

ECO No. 94/31
Víctor GÓMEZ/Agustín MARAVALL
Program TRAMO "Time Series Regression with ARIMA Noise, Missing Observations, and Outliers" - Instructions for the User

ECO No. 94/32
Ákos VALENTINYI
How Financial Development and Inflation may Affect Growth

ECO No. 94/33
Stephen MARTIN
European Community Food Processing Industries

ECO No. 94/34
Agustín MARAVALL/Christophe PLANAS
Estimation Error and the Specification of Unobserved Component Models

ECO No. 94/35
Robbin HERRING
The "Divergent Beliefs" Hypothesis and the "Contract Zone" in Final Offer Arbitration

ECO No. 94/36
Robbin HERRING
Hiring Quality Labour

ECO No. 94/37
Angel J. UBIDE
Is there Consumption Risk Sharing in the EEC?

ECO No. 94/38
Berthold HERRENDORF
Credible Purchases of Credibility Through Exchange Rate Pegging: An Optimal Taxation Framework

ECO No. 94/39
Enrique ALBEROLA ILA
How Long Can a Honeymoon Last? Institutional and Fundamental Beliefs in the Collapse of a Target Zone

ECO No. 94/40
Robert WALDMANN
Inequality, Economic Growth and the Debt Crisis

ECO No. 94/41
John MICKLEWRIGHT/Gyula NAGY
Flows to and from Insured Unemployment in Hungary

*out of print

*out of print