

Milicevic, Teodora Borota; Carlsson, Mikael

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*Markups from Inventory Data and
Export Intensity*

Teodora Borota Milicevic and Mikael Carlsson

Department of Economics
Uppsala University
P.O. Box 513
SE-751 20 Uppsala
Sweden
Fax: +46 18 471 14 78

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MARKUPS FROM INVENTORY DATA AND EXPORT INTENSITY

TEODORA BOROTA MILICEVIC AND MIKAEL CARLSSON

Markups from Inventory Data and Export Intensity*

Teodora Borota Milicevic[†] and Mikael Carlsson[‡]

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Abstract

In this paper we propose a novel method for the price-cost markup estimation and study the relationship between export intensity and the markup. We impose much less restrictive identifying assumptions on technology and adjustment frictions compared to previous studies and use Swedish firm-level inventory data on finished goods of own production to measure the markup. Furthermore, as we are using data on a quarterly frequency, we are able to provide novel results on the dynamic adjustment of the markup related to changes in export intensity.

Keywords: price markups, export intensity, capacity utilization, exporter pricing

JEL classifications: D22, D24, F14, L11, L60

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[†]Uppsala University. e-mail: teodora.borota@nek.uu.se

[‡]Uppsala University, UCLS and Sveriges Riksbank. e-mail: mikael.carlsson@nek.uu.se

1 Introduction

The estimation of the price-cost markup as a measure of market power has long been of particular interest in the studies of industrial organization, trade and competition policy.¹ This paper proposes a novel method for the markup estimation and study the relationship between export intensity and the price-cost markup and its dynamics in Swedish mining and manufacturing firm-level data in the 1998:Q1-2013:Q1 period. We are able to impose much less restrictive identifying assumptions on technology and adjustment frictions compared to previous studies and use firm-level inventory data on finished goods of own production to measure the markup on a quarterly frequency.

The early empirical literature's interest in the estimation of industry- and firm-level markups is derived from a long-standing quest for a proper measurement of productivity and productivity growth. In turn, this necessarily requires a proper empirical identification of different aspects of productivity, such as technological change, returns to scale, capacity utilization and market power (markups). In one of the earliest parametric approach papers, Hall (1986) took markups into account when measuring marginal cost. The methodology attempts to capture marginal cost independently of average cost and as such can be used not only for measuring markups (the price-marginal cost wedge), but to determine the scale economies (the average-marginal cost wedge) as well.

In the spirit of Hall's (1986) markup estimation, De Loecker and Warzynski (2012) estimate markups using Slovenian micro-data. They rely on optimal input-demand conditions based on cost minimization and the identification of

¹For some early empirical methods and results, see e.g. part 3 of the Handbook of Industrial Organization (1989, vol. 2.).

output elasticities of variable inputs, which are less likely to be subject to adjustment costs. The markup is then the wedge between the output elasticity of a particular input and the input's share in total revenue. The main problematic issue with these types of studies are unobserved productivity shocks affecting input choice and output growth, thus biasing estimates of output elasticities and, in turn, markup estimates. De Loecker and Warzynski (2012) address this issue by using the notion of control function. The proposed methodology is then applied to study the relationship between trade liberalization and the markup. The availability of better quality and more detailed data fueled the development of several recent studies, which also control for relative price heterogeneity (of inputs and output) in the procedure; see e.g. De Loecker et al. (2016) and Lamorgese et al. (2016).

As in De Loecker and Warzynski (2012), our proposed method is also based on cost minimization, but it requires less restrictive assumptions on production technology and adjustment costs. Noting that the share of total cost in a firm's revenue is equal to the ratio of total average cost to product price, this ratio can further be equated to the ratio of the firm's returns to scale to the firm's price-cost markup. Using the data on the firm's revenue and total costs, the calculation of the markup is straightforward once one determines the returns to scale. However, to identify variation in the markup within the firm, we only need the firm's returns to scale to be time invariant. Using micro data on capacity utilization, we show that time-invariant returns to scale are indeed a good first approximation. Therefore, we can account for the returns to scale in the empirical estimation by the use of firm fixed effects when analyzing the relationship between export intensity and the (log) markup.

Unlike previous papers, we are studying a developed, mature open economy in which a large majority of firms have exports (93% of the observations in our

sample have positive exports). Accordingly, we focus on the intensive margin of export and analyze the relationship between firms' markups and export intensity (share of total sales placed in foreign markets), instead of analyzing the relationship between markups and trade liberalization or export market entry (extensive margin). We find that going from being a firm that trades almost exclusively on the domestic market to an export-focused firm is associated with around a 5% higher markup on average. These results are very similar to those in previous studies, which supports the robustness of the markup-export link regardless of the estimation method, the nature of the trading environment or the country. Our results also fit the theoretical predictions of heterogeneous firms trade models that feature variable markups. In e.g. Melitz and Ottaviano (2008), more productive firms (lower cost producers) have both higher markups and higher export shares.

As the data allows us to calculate the markup on a quarterly frequency, we are also able to provide novel results on the dynamic markup adjustment related to a change in export intensity. We find that the markup adjustment is relatively fast, lasting about two quarters, after which the markup settles at the new higher level. Previous empirical studies interested in markup dynamics have linked industry markup behavior and the business cycles.² Instead, we study the markup dynamics on the firm level, which we hope can provide guidance for the increasingly ambitious theoretical contributions to our understanding of markup behavior.³

²See e.g. Martins et al. (1996) who test the industry markups cyclicity in OECD economies.

³See e.g. Jaimovich and Floetotto (2008), Bilbiie et al. (2012), Ottaviano (2011), Alessandria and Choi (2009), in turn, building on Bilts (1987), Rotemberg and Woodford (1991, 1999) and Chevalier et al. (2003).

This paper is organized as follows: Section (2) outlines the theory for measuring the price-cost markup and discusses the method and the data. Section (3) reports the results and section (4) concludes.

2 Measurement, Data and Method

2.1 Measurement

Previously, measures of markups have been based on annual production data and identified by restrictions on production technology and adjustment costs combined with the assumption about cost minimization (see e.g. Hall, 1986, 1988, 1990, Roeger 1995, Basu and Fernald 1997, Klette 1999, De Loecker and Warzynski, 2012). The approach taken in this paper also relies on cost minimization, but imposes minimal restrictions on technology and adjustment costs, or by duality, the cost function, which is a more relevant concept in our case. We start from the following relationship between the ratio of the firm's production value, $P_{jt}Y_{jt}$, and the total cost of production, C_{jt} , on the one hand, and the ratio of the markup of price over marginal cost set by the firm, μ_{jt} , and the firm's returns to scale, γ_j , on the other hand, i.e.

$$\frac{P_{jt}Y_{jt}}{C_{jt}} = \frac{\mu_{jt}}{\gamma_j}, \quad (1)$$

where j indexes firms and t indexes time, and where we have used that $\gamma_j = AC_{jt}/MC_{jt}$.⁴ This relationship will hold for a cost minimizing firm as long as the cost function fulfills standard regularity conditions (see Appendix A.1).

⁴See Varian (1992) pp. 88 for a proof. To derive equation (1), notice that $\frac{P_{jt}Y_{jt}}{C_{jt}} = \frac{P_{jt}}{AC_{jt}} = \frac{P_{jt}}{\gamma_j MC_{jt}} = \frac{\mu_{jt}}{\gamma_j}$.

The firms' returns to scale, γ_j , are regularly treated as constant (time invariant) in the literature, both in papers presenting empirical measures of markups (discussed above) and in papers aimed at directly estimating the returns to scale (see e.g. Basu and Fernald 1997, Hall 1990, Domowitz et al. 1988, Burnside et al. 1995). Taking the same route, we can then identify the variation in the markup within a firm by removing the time average for the firm from the log of expression (1). This is the approach taken in the regression analysis in this paper, by means of including firm-fixed effects.

In a more convoluted case, allowing for a fixed factor of production in the short run, γ_j will be a local measure of the returns to scale, i.e. the elasticity of scale and it should be denoted by γ_{jt} . Formally,

$$\gamma_{jt} = \gamma_j \kappa_{jt} = \left[\frac{C_{jt}^*}{MC_{jt}^* Y_{jt}^*} \right] \left[\frac{MC_{jt}^* Y_{jt}^*}{MC_{jt} Y_{jt}} \frac{C_{jt}}{C_{jt}^*} \right], \quad (2)$$

where C_{jt}^* is the shadow cost function corresponding to the steady state where the fixed factor demand is such that its shadow value to the firm and its market price are equalized.⁵ MC_{jt}^* and Y_{jt}^* stand for the marginal cost and the output level, respectively, corresponding to the steady state with total cost C_{jt}^* . The term in the first square brackets is thus the long-run steady state measure of returns to scale, γ_j , while we define the second squared brackets term as the cost side measure of capacity utilization, κ_{jt} . When capacity utilization is at the steady-state level, then $C_{jt} = C_{jt}^*$ and the returns to scale are equal to their long-run value, $\gamma_{jt} = \frac{AC_{jt}^*}{MC_{jt}^*} = \gamma_j$. However, given the capacity utilization wedge between the long and short-run economies of scale, we need to address the scale economies more carefully.

With the non-convexities in technology coming from the fixed costs, the MC_{jt} schedule will cut the AC_{jt} schedule at its minimum. This point is

⁵See Morrison (1993), chapters 3 and 4

usually termed the minimum efficient scale. At this point, all scale advantages are exhausted and the local elasticity of scale is unity. Since all factors are adjustable over time, in perfectly competitive output markets the firm will aim to adjust its production capacity on average close to the efficient scale in order to maximize profits ($p_t = MC_t = AC_t$).⁶ With some degree of market power, firms may optimize their production plans at the levels lower than the efficient scale. In the short run, deviations around the optimal point occur, but the firm will again aim to settle at the long-run profit maximizing point and stable economies of scale. Therefore, the returns to scale will in general be a function of production relative to capacity, but for the outlined identification strategy to make sense, this function must not be too steep. If this requirement is satisfied, the elasticity of scale can again be regarded as constant, i.e. $\gamma_{jt} = \gamma_j$. Using a quarterly firm-level survey measure of capacity utilization, we will argue that this function is indeed essentially flat.

2.2 Data

The micro-level data needed for measuring (1) are available in most firm-level data sets containing production data. However, for Sweden we can actually compute (1) on the quarterly frequency using data from Statistics Sweden’s survey “Konjunkturstatistik för Industrin” (KI) program, which is designed to shed light on the business cycle situation in the industrial (mining and manufacturing) sector. Specifically, we rely on survey questions about the sales value (expected or realized) of the inventories of finished goods produced by

⁶See Mas-Collel et al. (1995) section 5.D. Interestingly, estimates of the returns to scale are often reported to be close to unity, see e.g. Basu and Fernald (1987), or Carlsson et al. (2014).

the firm, $P_{jt}Y_{jt}$, and the total costs for producing these inventories, C_{jt} . In the instructions, the survey respondents are asked to include all costs associated with the manufacturing and production of a product. Production costs usually consist of direct material costs, indirect material costs, direct labor costs and indirect production costs. Indirect production costs include e.g. capital costs for buildings and machinery, operating costs, maintenance and wages of supervisors. Importantly, the data also allow us to calculate the turnover rate of the inventory stock to address concerns about using data on inventories rather than production/sales directly.

In the KI program, Statistics Sweden surveys about 2000 industrial firms each month. However, the questions on inventories are only asked on a quarterly basis and the data used here covers the first available period, 1998:Q1 to 2013:Q1. The survey sample is stratified according to the firm size and firm sector. The strata with the largest firms (varying from over 200 or over 500 employees in the sample period) include all firms, whereas smaller firms strata (down to a minimum of 10 employees) include only a sample of firms. The firm sample changes once a year: some firms join and some exit the survey. Moreover, the firm size cut-off for mandatory inventory reporting used here changed from 10 employees to 50 employees in the first quarter of 2001. The data is organized around observation identities that cover the plants, or a sub-group of the plants, classified as belonging to the industrial sector of a firm. Thus the observation identity does not correspond one-to-one with the firm concept. To get a proper handle on the object of study, we focus our analysis on the plant level instead by only using observation numbers that correspond to a unique plant (during all months) in each quarter. From 2004, the definition of an observation identity changes from plants within a firm to lines of businesses (*verksamhetsenheter*) within a firm. Unfortunately, a line

of business potentially cuts through different plants within a firm. To handle this issue, we remove the few cases in which the *verksamhetsenhet* concept is different from the plant concept. This shift in focus is also useful since we want to control for industry-time effects in the empirical approach and we only have access to industry classifications at the (regular) firm and plant levels.

After removing missing and inconsistent observations, as well as observations with no inventories of finished goods of own production, the inventory data contains 2666 observation numbers (starting from 4584 observation numbers) and 43370 observations. Then, focusing on single-plant observation numbers (within quarter) and merging on industry code (NACE) from the Statistics Sweden “Registry Based Labor Market Statistics” (RAMS) database we are left with 2206 observation numbers, corresponding to 1877 plants and 32016 observations. Moreover, to compute the export share (export deliveries divided by total deliveries) we add on information on deliveries of products of own production by destination (home/export market), which is available on a monthly basis in the KI program. We also add on a survey question about capacity utilization, which we use for testing the assumption about the time-invariant returns to scale. In the latter question, respondents are asked to state the capacity utilization compared to typical in percentage terms. Here, according to the instructions given to the respondent, full capacity refers to the production level that can be achieved with existing machinery and current production methods (working hours, shift work and product mix that can be considered normal for the plant in the quarter under consideration), disregarding seasonal factors like vacations. Moreover, capacity utilization can exceed 100%, for example when overtime is high or when extra shifts are temporarily deployed. Finally, if action is taken with the intention of permanently altering production capacity, the new situation should be regarded as normal. This

leaves us with a data set covering 1784 plants and 29218 observations. To handle some extreme observations in the ratio of sales value to cost, we also trim the data by removing the 0.25% most extreme observations in this variable in both tails of the distribution. The final sample thus consists of 1783 plants and 29072 observations.

Table 1: Summary Statistics

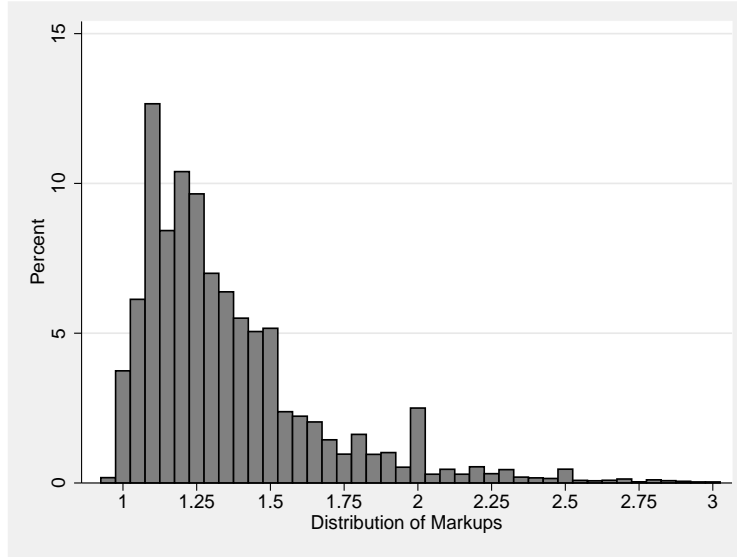
VARIABLES	Number of observations	Mean	S.d.	Min	Max
Markup	29072	1.393	0.437	0.941	5.522
Export share	29072	0.490	0.332	0	1
Capacity utilization	29072	0.871	0.155	0	1.500
Inventory turnover	29072	29.48	1303	0.005	158020

Note: Summary statistics for the baseline data set across all observations for the 1783 plants.

Table 1 presents summary statistics for the final sample. Row 1 of Table 1, labeled Markup, presents the ratio of the firm’s production value and total cost, $\frac{P_{jt}Y_{jt}}{C_{jt}}$. This measure consists of the markup divided by the returns to scale and as can be seen in Table 1, averages 1.39. Carlsson et al. (2014a) report estimates of the returns to scale close to unity for the Swedish manufacturing sector relying on a panel of annual firm-level production data. For this reason, we refer to the measure in row 1 as the markup in this section.⁷ Interestingly, assuming an isoelastic demand function, the average markup implies an elasticity of demand of 3.54, which is very close to the estimate of the elasticity of demand of 3.31 reported by Carlsson et al. (2014b) for the

⁷For the regression analysis presented below we can relax the assumption of constant returns to scale. There we only need the returns to scale to be approximately constant over time within the plant.

Figure 1: Markup Distribution



Swedish manufacturing sector using the same methodology as in Foster et al. (2008). In turn, this result also implies that the returns to scale are likely to be close to unity since deviations from unity would drive a wedge between the two estimates of the demand elasticity.

Figure 1 depicts the distribution of the markup data. The shape is right skewed and shows signs of bunching at some points, most distinctively at a markup of 1.5 and 2.

In the Export share, row 2 of Table 1, we report that about half (49%) of what is delivered from these plants is destined for the export market. In fact, it is quite uncommon in this sample not to export at all. Only 7% of the observations on export share are equal to zero.

In the Capacity utilization row of Table 1, we report that the plants use 87% of their normal production capacity on average, but that the utilization ranges from zero (stand-still) to 150% when, presumably, extra shifts of workers are

deployed.

Finally, the Inventory turnover row presents statistics on the value of total deliveries of products of own production divided by the value of the stock of finished goods of own production. On average, the deliveries are almost 30 times the size of the inventory stock. Thus, we should not expect any problems with large stocks of inventories relative to deliveries, which are potentially hard to value by the respondents in the survey. However, below we will explore whether the inventory turnover rate affects the results in the regressions.

2.3 Method

The baseline specification in the regression analysis can be written as

$$\ln \mu_{jt} = \alpha_j + \beta EXP_{jt} + \lambda_{st} + \epsilon_{jt}, \quad (3)$$

where α_j is a plant-fixed effect, EXP_{jt} is the export intensity and λ_{st} is sector (two-digit NACE) by time dummies. The later dummy is included to control for sector-specific trends/shocks. In this benchmark model, we include the plant-fixed effects to absorb the returns to scale of the plant. To control for the potential time variation in the returns to scale, we subsequently also include the measure of capacity utilization in the regression model. Finally, we also experiment with conditioning on the inventory turnover rate being larger than unity. The model is then estimated using OLS. Note that we do not interpret β as a causal parameter. Here, we are only interested in investigating whether an export-focused firm has a higher markup than a firm trading almost exclusively on the domestic market on average.

3 Results

In this section we present the main results of our empirical analysis. Table 2 reports the results from regressing the log markup on export intensity. Depending on the specification, we include plant and sector/time fixed effects.

Table 2: Markups and Export Intensity

	(1)	(2)	(3)
EXP _{jt}	0.057** (0.004)	0.039** (0.007)	0.048** (0.007)
Observations	29072	29072	29072
Number of Plants	1783	1783	1783
Plant FE	No	Yes	Yes
Sector/Time FE	No	No	Yes

Note: Dependent variable $\ln\mu_{jt}$. Standard errors in parentheses, ** $p < 0.01$, * $p < 0.05$.

Export intensity proves to be significant in all specifications and the point estimates are fairly insensitive to including firm and sector/time-fixed effects. Going from being a firm trading almost exclusively on the domestic market to an export-focused firm is associated with around a 5% higher markup on average. Interestingly, this result is very close to the one found in De Loecker and Warzynski (2012) studying the relationship between export entry and markups using Slovenian data. Moreover, the finding here is in line with theory. In e.g. Melitz and Ottaviano (2008), more productive firms (lower cost producers) have both higher markups and higher export shares. Further contributions to the theoretical literature suggest that these advantages come from firms' incentives to invest in innovation and to export the upgraded products; see

e.g. Bustos (2011) or Kugler and Verhoogen (2012). Unfortunately, the data does not permit a further exploration into these issues.

Table 3: Identification and Robustness

	(1)	(2)	(3)
EXP _{jt}	0.048** (0.007)	0.051** (0.007)	0.048** (0.007)
Capacity utilization _{jt}			0.005 (0.007)
Observations	29,072	27,414	29,072
Number of Plants	1,783	1,751	1,783
Plant FE	Yes	Yes	Yes
Sector/Time FE	Yes	Yes	Yes
Inventory turnover _{jt} > 1	No	Yes	No

Note: Dependent variable $\ln\mu_{jt}$. Standard errors in parentheses, ** p<0.01, * p<0.05.

Table 3 reports the results of regressing the log markup on export intensity, where we also condition on a high inventory turnover rate (i.e. only using observation where this variable is larger than unity).⁸ The results are robust and are shown in Column 2, where the point estimates on export intensity coefficient increase slightly. Most importantly, in Columns 3 we report the results of the specification which controls for capacity utilization. The coefficient estimate on the export intensity is unaffected; the coefficient estimate on capacity utilization is economically very small and proves to be statistically insignificant, justifying our assumption on the stable (time-invariant) returns to scale.

⁸Column 3 of Table 2 is repeated as Column 1 in Table 3 for convenience.

Table 4: Markup Dynamics

	(1)	(2)
EXP _{jt}	0.048** (0.007)	0.029** (0.011)
EXP _{jt-1}		0.028** (0.011)
EXP _{jt} +EXP _{jt-1}		0.057** (0.008)
Observations	29072	24795
Number of Plants	1783	1595
Plant FE	Yes	Yes
Sector/Time FE	Yes	Yes

Note: Dependent variable $\ln\mu_{jt}$. Standard errors in parentheses, ** p<0.01, * p<0.05.

Finally, in Table 4 we investigate the markup dynamics by including the lagged values of export share in the main specification, where the latter specification is repeated in the first column.

The one-quarter lagged export share is significant and the weights on the current and lagged export share are very similar, equal to roughly one half of the current export intensity coefficient when the lag is omitted. The markup adjustment thus seems to be fast and completed within two quarters. Also, the sum of coefficients is statistically significant and slightly larger than the baseline estimate (0.06 vs. 0.05).⁹

4 Conclusion

We proposed a novel method for the price-cost markup estimation which we apply to study the relationship between export intensity and the markup and its dynamics in Swedish mining and manufacturing firm-level data in the 1998:Q1-2013:Q1 period. Following Hall (1986) and De Loecker and Warzynski (2012), the method in our paper is based on cost minimization, but requires less restrictive assumptions on production technology and adjustment costs. We use firm-level inventory data on finished goods of own production to measure the markup and firm-level data on capacity utilization to confirm the identifying assumption of returns to scale being time-invariant within a firm.

We are analyzing a mature open economy with a large share of exporting firms and focus on the relationship between the intensive margin of export (share of total sales placed in foreign markets) and firms' markups, as opposed to the extensive margin (trade liberalization or export market entry) which

⁹Computing more conservative standard errors for our main results, summarized in Table 4, by clustering on the plant level results in, as expected, a somewhat weaker coefficients' statistical significance - 5% significance of the current export share coefficient in the baseline specification, and 11% and 6% on the current share and one-quarter lagged export share, respectively, when the lag is included to account for dynamics. The latter two coefficient estimates are jointly significant at 5% however.

was used in previous studies on developing economies. We find that changing from being a firm trading almost exclusively on the domestic market to an export-focused firm is associated with around a 5% higher markup on average. These results are very similar to those in previous studies, which supports the robustness of the markup-export link regardless of the estimation method, the nature of the trading environment or the country.

Exploring the data at quarterly frequency, we were also able to provide novel results on the markup dynamics. The markup adjustment related to changes in export intensity proves to be relatively fast, lasting about two quarters, after which the markup settles at the new level. The previous literature has focused on the business cycle dynamics of the industry markup. Here, instead, we are studying the markup dynamics on the firm level, which we hope can provide guidance for the increasingly ambitious theoretical contributions to our understanding of markup behavior.

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Appendix

A The Cost Function

A.1 Regularity Conditions on the Cost Function

As in Morrison (1993, ch.5), we define the total cost function as

$$C(Y, p, t) = \min_v (p^T v : f(v, t) \geq Y)$$

where $(p_1, p_2, \dots, p_J) = p \gg 0_J$ is a vector of J input prices (assuming no monopsony) and the production function is $Y = Y(v, t)$ with v as a vector of J variable inputs. Then, if the solution to cost minimization exists, it must satisfy the following regularity conditions:¹⁰

- i) $C(\cdot)$ is nonnegative ($C(Y, p, t) \geq 0$)
- ii) $C(\cdot)$ is (positively) linearly homogeneous in input prices for any fixed output level ($C(Y, \mu p, t) \equiv \mu C(Y, p, t)$ for $\mu > 0$)
- iii) $C(\cdot)$ is increasing in prices ($C(Y, p_1, t) > C(Y, p_0, t)$ if $p_1 > p_0$ or $\frac{\partial C}{\partial p_j} > 0$)
- iv) $C(\cdot)$ is concave in p ($\frac{\partial^2 C}{\partial^2 p_j} \leq 0$, informally)
- v) $C(\cdot)$ is continuous in p and continuous from below in Y
- vi) $C(\cdot)$ is non-decreasing in Y for fixed p ($C(Y^0, p, t) \leq C(Y^1, p, t)$ for $Y^0 \leq Y^1$ or $\frac{\partial^2 C}{\partial^2 Y} > 0$)

When the above conditions are satisfied, the cost function is valid for analysis on firm behavior and the reversed process can be applied to reconstruct the

¹⁰Morrison (1993), ch.5, pp 118.

underlying production technology (by recovering the isoquants). Furthermore, adding a fixed input K (or analyzing the “short term”) does not violate the properties. One only needs to distinguish between variable (v) and fixed (K) inputs and denote the production function by $Y(v, K, t)$ and the cost function by $G(Y, K, p, t)$.

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