ISSN 2279-9362

Collegio Carlo Alberto

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No. 373
December 2014

Carlo Alberto Notebooks

www.carloalberto.org/research/working-papers

THE MEASUREMENT OF PRODUCTION: LESSONS FROM THE ENGINEERING INDUSTRY IN ITALY, 1911

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November 2014

ABSTRACT

This paper presents the second-generation estimates for the Italian engineering industry in 1911, a year documented both by the customary demographic census, and the first industrial census. The first part of this paper uses the census data to estimate the industry's value added, sector by sector; the second further disaggregates each sector by activity, and estimates the value added, employment, physical product, and metal consumption of each one. A third, concluding section dwells on the dependence of cross-section estimates on time-series evidence. Three appendices detail the specific algorithms that generate the present estimates; a fourth, a useful sample of firm-specific data.

THE MEASUREMENT OF PRODUCTION: LESSONS FROM THE ENGINEERING INDUSTRY IN ITALY, 1911

This paper documents the second-generation estimates for the Italian engineering industry in 1911; as usual, its focus is as much on method as on results.[1] Because of the State's heavy involvement as a regulator and often a direct customer, the shipbuilding and railway-vehicles industries are exceptionally well-documented; the corresponding (national and regional) second-generation estimates are already in the public domain.[2] The rest of the engineering industry received no more than sporadic, partial attention, and the industry-specific sources provide only scattered data points.[3] The reconstruction of the corresponding time series can and must make use of them, but will perforce be based very largely on indirect evidence and on general sources. The present concern is with the derivation of a suitable initial benchmark -- and with the methodological considerations it suggests.

The general evidence for 1911 is particularly abundant, as in June the Census Bureau took Italy's first industrial census as well as its fifth demographic census.[4] It is used here to generate an initial set of disaggregated estimates that can then be reproduced for the previous census years, and finally extrapolated into annual series; within the constraints imposed by the surviving evidence; these estimates are designed to distinguish activities characterized by significant differences in value added per relevant unit, and in the time path of production.

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[1] For a recent overview see S. Fenoaltea, "The Reconstruction of Historical National Accounts: The Case of Italy," *PSL Quarterly Review*, 63,.2010, pp. 77-96. The new estimates documented here supersede the preliminary figures in S. Fenoaltea, "Il valore aggiunto dell'industria italiana nel 1911," in G. M. Rey, ed., *I conti economici dell'Italia. 2. Una stima del valore aggiunto per il 1911*, Collana storica della Banca d'Italia, serie "statistiche storiche," vol. I.II, Bari 1992, pp. 147-156.

[2] C. Ciccarelli and S. Fenoaltea, "Shipbuilding in Italy, 1861-1913: The Burden of the Evidence," *Historical Social Research*, 34, no. 2, 2009, pp. 333-373; Id., Id., "The Rail-Guided Vehicles Industry in Italy, 1861-1913: The Burden of the Evidence," *Research in Economic History*, 28, 2011, pp. 43-115. The precious-metal products industry is also set aside: maintenance is assumed negligible, and the time series is derived directly from the value added estimate in Table 3.

[3] Istat (Istituto centrale di statistica), *Le rilevazioni statistiche in Italia dal 1861 al 1956*. Annali di statistica, Serie VIII, vol. 5 - 8, Rome, 1957-59; see vol. 7, pp. 361 ff. A review of the sources cannot be provided here, but is available on request.

[4] Ministero di agricoltura, industria e commercio, Ufficio del censimento, *Censimento degli opifici e delle imprese industriali al 10 giugno 1911*, 5 vols. (Rome, 1913-16), henceforth *Censimento industriale*; Id., Id.,. *Censimento della popolazione del Regno d'Italia al 10 giugno 1911*, 7 vols. (Rome,1914-16), henceforth *Censimento demografico*. The distribution of the population of working age (10+), by age, sex, and sector, appeared in vols. 4 (for small administrative units, from the municipality to the province) and 5 (for the regions and the Kingdom); with limited exceptions the classification of industrial activities was the same as that used in the industrial census. The two censuses together are here referred to simply as the *Censimenti*.

The procedure involves two essential moments, summarized in the two main parts of this paper; a full account is available on request. The first generates estimates of the aggregate value added of each of the (residual) engineering industry's components sectors. These are derived directly from the census data (and ancillary evidence of labor and capital costs per worker and per horsepower). A proper use of the data in the sources requires a proper understanding of their actual content: a truism, no doubt, but one the literature honors mainly in the breach.[5]

The second further disaggregates each sector to estimate the value added, employment, physical product, and metal consumption of each of its major activities. These estimates are constrained by the disaggregated census data, the evidence on commodity prices and input-output ratios, and, not least, the industry's aggregate metal consumption; this last is of particular significance, as the available annual series provides a joint constraint on the final time-series estimates for the engineering industry. The most relevant distinctions, within each sector, are of course those between labor-intensive, stock-related maintenance on the one hand and (normally) metal-intensive, stock-adjusting new production on the other; also, within the latter, between simple products and complex ones (e.g., truss-structure components and machinery, both "heavy engineering"), and again between ("normal") production from metal and (exceptionally) the mere assembly of imported parts.

The third part of the paper dwells on the methodological considerations suggested by the preceding exercise: what it highlights, in fact, is the inherent weaknesses of cross-section estimates built up without concern for the corresponding time series.

I. THE PRODUCT OF THE ENGINEERING INDUSTRY IN 1911

1. The 1911 censuses

The contents of the 1911 censuses have been described elsewhere; they are briefly recalled here, for the reader's convenience.[6] The *Censimento demografico* used the questionnaire sent to each individual to assign the population aged 10 or more to a detailed set of agricultural, industrial, and service activities, or to the non-working population; for each economic activity, it provides data on the corresponding labor force.[7]

The labor-force data provided by the *Censimento demografico* are relevant because the *Censimento industriale* is badly incomplete; and it is incomplete because the attempt to coordinate the two censuses simply miscarried.[8] The intention was to gather the data for the industrial census on three separate questionnaires. Two were specific to that census: the one sent to every separate ("small") industrial workshop, with one to ten subordinate workers in addition to the owner/manager, and the one to every ("large") separate industrial workshop

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[5] Or "in the breech," as a colleague once wrote, conjuring up wonderfully improper images. Fenoaltea, "The Reconstruction," specifies four rules; Rule 1 is "the data must be vetted."

[6] S. Fenoaltea, "Industrial employment in Italy, 1911: the burden of the census data," *Carlo Alberto Notebooks*, No. 372, December 2014.

[7] See for example *Censimento demografico*, vol. 4, pp. 3-6.

[8] See *Censimento industriale*, vol. 5, pp. 22-26.

with more than ten subordinate workers. Data on the remaining industrial activity ("not separate" from the owner/manager's residence, or even if thus separate, by the owner/manager who worked alone) was to be documented by a third questionnaire, on the back of the individual demographic form for each head of household. This last questionnaire did not produce useful information; the published figures report only the data gathered in the replies to the first and second, singly (respectively vol. 2 and vol. 3) and combined (vol. 4).

Artisans working alone, or in a place not separate from where they ate and slept, were omitted: that much is declared outright. A subtler issue concerns the relevant physical separation. To avoid duplication, it would seem, the census takers sent only the appropriate questionnaire *to each street address*: and since each residential address necessarily received the demographic form, the industrial census appears to have omitted whatever factories adjoined their owner's dwelling and shared a common street address. The censuses seem never to say as much; but there is evidence to that effect even within their data. At times, the members of the labor force missed by the industrial census are very largely artisans or owner-managers, suggesting that most may indeed have worked alone or in their residential quarters; at other times, even allowing for the likely incidence of unemployment, the share of hirelings is so high as to point very strongly to omitted factory workers.

When all is said and done the *Censimento industriale* counted a mere 2.3 million industrial workers, against 4.3 million in the *Censimento demografico*. Some of the latter were no doubt unemployed (but not many, at the peak of the pre-War boom), others no doubt "domestic workers" who worked little if at all; but the industrial census missed nearly half the *male* labor force, and of these omitted males, at least, all but a few were surely working, of necessity, to put bread on the table.

The industrial employment counted by the published industrial census is thus to be complemented by an estimate of the employment it omitted; and that estimate relies perforce on the labor force data in the demographic census. Clearly, too, the difference between the two census figures must be evaluated case by case, as the incidence of unemployment and the relative productivity of the omitted employed workers vary industry by industry. Obviously, unemployment depends on the growth rate of the industry's product, and perhaps on major technological shocks (such as, famously, the invention of the power loom). Equally obviously, relative productivity depends overwhelmingly on the relative similarity of the work performed by those the industrial census counted, and those it missed. In some industries, the former may have been overwhelmingly workers in mechanized factories, the latter mostly artisans tied to traditional hand processes (and who may have worked very little, as in the notorious case of the Calabrian housewives who were counted as weavers); but in other industries modern factory production had yet to take root, and the artisans the industrial census missed are in fact indistinguishable from those it happened to count.

But the labor-force data in the demographic census must also be handled with due care, for they are not always, as one might think, upper bounds to actual employment. The undercounting of (full-time-equivalent) workers is again obvious in the case of activities, like the processing of perishables, that provide employment for only a few weeks out of the year, and correspondingly lack a dedicated labor force. A subtler case in point is that of more broadly seasonal activities that were dormant in June: for example, the same workers quarried clay in winter and fired it in summer, and the demographic census tends to count them simply as brick-makers. But the vertical integration of production causes more general distortions, shifting worker counts to the last stage of production: the integrated production of sulphuric acid and superphosphates, for example, meant that many workers in the acid plants reported themselves as producers of chemical fertilizer.

Nor is that all. Most industries make use of unskilled labor, if only to fetch and carry, and unskilled labor moves readily from one sector to another. Industries under abnormal demand pressure tend to suck in temporary help from other sectors of the economy; and an agricultural day-laborer employed on a construction project may well report his usual occupation, rather than his current one, on his census form.[9]

Actual industrial employment is in general understated by the industrial-census "employment" data, and overstated by the demographic-census "labor force" data: but only in general, and not at all necessarily in the case of any specific industry.

2. The engineering industry

In the 1911 *Censimenti*, all metal processing from ore to finished product is included in category 4. The transformation from ore to semi-finished metal (or castings) is covered by *classi* 4.1 and 4.2; subsequent metal processing is distributed over *classi* 4.3 (hardware, metal furniture, other fabricated metal), 4.4 (structural components, industrial and agricultural machinery, and transport equipment other than wood carts, carriages, and sleighs, and wood boats not built in yards, counted in categories 3.15 and 3.16, respectively), and 4.5 (precision instruments, clocks and watches, office equipment, firearms and ordnance, metal musical instruments, and jewelry and related articles). *Classi* 4.1 and 4.2 are here identified with the metalmaking industry; the engineering industry is in turn defined as the set of activities that characterize *classi* 4.3, 4.4, and 4.5.

This industry is substantially that covered by *ISIC* category 38 (manufacture of fabricated metal products, machinery, and equipment); the principal differences are that the present industry excludes the manufacture of wood carts, carriages, and sleighs (part of 3849), and wood boats not built in yards (part of 3841), but includes the manufacture of jewelry and related articles (3901), metal musical instruments (part of 3902), and knitting needles, pen nibs, and the like (part of 3909), and also, apparently, the repair of electrical appliances (9512), motor vehicles (9513), watches, clocks, and jewelry (9154), and other equipment (9519).[10] The general repair services of blacksmiths and the like, and the specialized services of shipyards and railway repair shops are included in the present industry and also in *ISIC* category 38 (3811, 3841, 3842); the typically low-level maintenance carried out within households, or within firms that lacked a separate maintenance shop (and therefore employed no professional mechanics, to judge from the similarity of the *Censimento demografico* and *Censimento industriale* figures for category 4.4), are excluded from the present industry and also from *ISIC* category 38.

The engineering industry in the *Censimenti* appears systematically to include maintenance as well as new production, as it does not, illogically, in the *ISIC*. This is suggested in the first instance by the underlying legislation, as the *Censimento industriale* did not distinguish between *arti* (crafts), *mestieri* (trades), and industry more strictly defined (*regio decreto 6, 1910, n. 776*, art. 23). It is also implied both by the census legends and by the census data. One the one hand, there are in the *Censimento demografico* no separate service-sector categories for repair work akin to those in the *ISIC*. Moreover, the wholesale and retail trades (categories 9.1 – 9.3) seem narrowly defined, as evidenced by the fact that they include only owners, white-collar workers (*impiegati*), cleaning staff and the like (*personale di servizio*), and porters (*facchini*, carriers of burdens), to the exclusion of workers who process goods (*operai*); processing was clearly (and not unreasonably) considered industrial work, to the point that

[9] On the direct evidence of this phenomenon at the regional level see Fenoaltea, "Industrial employment."

[10] United Nations, *Indexes to the International Standard Industrial Classification of All Economic Activities*, Statistical Papers, Series M, No. 4, Rev. 2, Add. 1, New York, 1971; briefly *ISIC*.

category 9.15, bread and pasta shops, is specifically said to refer only to the (re)selling of goods manufactured by other concerns. Finally, as will be made clear below, the very size of the labor force attributed to the engineering industry (and the resulting average metal consumption per worker) implies that much of it was perforce engaged in repair work, especially in the small shops (including those missed by the *Censimento industriale*), and this on a scale that readily accommodates consumer as well as producer durables. More specifically, the many thousand "watchmakers" counted in industry (4.53) were no doubt very largely traditional shopkeepers who sold watches but mostly repaired them; the selling of watches is specifically included with that of other luxury goods in (trade) category 9.115, but (as with the selling of bread and pasta) the intent of the census was surely to count there only those whose activity was strictly, or at least overwhelmingly, mercantile.

The importance of the repair services it includes makes the engineering industry somewhat *sui generis*. In principle, maintenance is production like any other, transforming physical inputs (goods in a certain condition) into physical outputs (goods in a different condition); in practice, at the relevant levels of aggregation the heterogeneity of inputs and outputs is such that a meaningful physical measure of production can hardly be obtained. Maintenance is accordingly measured only by its value added; new production is instead measured by physical output as well. Because new parts can be used for maintenance as well as new production (and also, as usual, because parts can be traded internationally), secondly, one should in principle distinguish systematically between the production of new parts from semi-finished metal, the assembly of new machines from parts, and the maintenance (partial disassembly and reassembly) of existing machines. In practice, this vertical disaggregation within individual sectors is rarely carried out: in general, the production of parts for new machines is included in machine production, the production of replacement parts is included in maintenance, and the mere assembly of imported parts is separately considered only where the trade data identify significant flows.

The shipbuilding and railway-vehicles industries apart, as noted, the engineering industry is very poorly documented. Because of these data limitations, the engineering industry is here disaggregated to distinguish, somewhat unusually, the following sectors: fabricated metal; ship building and repairing; rail-guided vehicles; "general equipment" (structural components and non-precision machinery); precision instruments; clocks and watches; precious-metal products.[11] The physical production estimates (for non-precious metal products) are individually constrained by the relevant prices and technical coefficients, and jointly constrained by the metal available to the industry.

3. The factor-employment data and estimates

Since there is so little direct evidence on the composition of the industry's output, and unit value added can vary within broad limits, aggregate value added in 1911 is here estimated from the activity levels suggested by the census reports. The relevant data are taken to be those for categories 4.3, 4.4, and 4.5, on the understanding that these cover the relevant maintenance and repair work as well as new production.

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[11] All these major components of the engineering industry are considered to be vertically independent, with one exception: the ship building and repairing industry is taken to fabricate the vessels' hulls, but only to install hardware and machinery obtained from the fabricated metal and machinery industry. In principle, the construction of electric locomotives should similarly allow only for the installation of ("purchased") electrical equipment; in practice, electric locomotives have simply been assimilated to the far more numerous steam locomotives.

The census labor force and factor employment data for categories 4.3, 4.4 and 4.5 are collected in Table 1. The *Censimento industriale* data for all shops, large shops, and small shops are taken from vols. 4, 3, and 2, respectively; the classification includes additional categories, marked by an ω in the appropriate position, for integrated shops. In the industrial census, the members of the owner's family are separately counted (and particularly numerous, not surprisingly, in the small shops), and the listed blue-collar workers are by implication only hirelings. In the demographic census, the members of the owner's family are not separately counted; but the internal evidence suggests that they were counted as owners, and that there too the listed blue-collar workers are only (or almost only) hirelings.[12]

Since the quoted industrial-census figures are to be inflated by the relevant employment in integrated shops (counted in categories 4.ω, ω.31, and ω.71), the industries of category 4.4 appear to have been completely covered by the industrial census; and this in turn implies that their shops were (almost always) well separate from their owners' dwellings, perhaps because of their noxious sounds and emissions.[13] Last but far from least, too, the similarity between the two sets of census figures for category 4.4 clearly implies that in those branches of the engineering industry, at least, unemployment was altogether negligible.

In categories 4.3 and 4.5 the differences between the corresponding sets of census figures are much more significant than in category 4.4, even allowing for employment in integrated shops; but it seems reasonable to assume that unemployment was negligible in categories 4.3 and 4.5 as well, and accordingly to interpret those differences as employment in works the *Censimento industriale* simply missed, either because they were one-man shops, or because regardless of size they shared their owner's residential address. One reason is that the differences between the census figures are particularly significant in categories 4.31 and 4.32 (smiths), where very small-scale operations were no doubt numerous, another, that the time series evidence suggests that over the preceding years production had grown far beyond its previous levels; but the strongest is that it is very hard to imagine that unemployed workers with metal-bashing skills would not have spread themselves throughout the industry, that there could have been a long queue for jobs in some sectors of the engineering industry (4.3, 4.5) even as there was no queue in others (4.4). Given on the one hand that some unemployment must surely have been present, if only because of illness, and on the other the above-noted tendency of the labor force data in the *Censimento demografico* to omit workers that booming industries (such as the one at hand) hired away from other sectors, total employment is here simply taken to have coincided with the recorded labor force; but a disaggregation of that total to separate the operations covered by the *Censimento industriale* from those it missed serves both to illustrate the structure of the industry and to refine the estimates of (unduplicated) horsepower in use and value added.

[12] In category 4.4 the demographic census lists no artisans (curiously, not even in category 4.43, which includes bicycles), and the differences between the two sets of aggregate census labor figures are exceedingly small (ca. 2%). The demographic census counts 14,429 owners (none under 15, but 752 under 21), 8,580 white-collar workers, and 136,392 blue-collar workers, while the industrial census lists 9,002 owners, 8,438 white-collar workers, 4,748 family members, and 133,814 blue-collar workers. The "owners" and "family-members" of the industrial census, together, correspond closely to the "owners" of the demographic census, and the figures for blue-collar workers in the two censuses are again close to each other.

[13] The relative differences between the two sets of census figures are greatest in the case of the aircraft industry, category 4.45, which at that time involved wood and cloth far more than metal; but they are readily accounted for by category ω.31.

The data in Table 1 are here recombined, and partly aggregated, into the estimates of actual factor employment presented in Table 2. Cols. 1 – 3 and 4 – 6 there refer to the large shops and small shops, respectively, covered by the *Censimento industriale*; in general, these estimates inflate the census data for specialized shops to absorb the workers and horsepower of the non-specialized shops. Cols. 7 – 9 refer in turn to the shops missed by the *Censimento industriale*, and cols. 10 – 12 to the industry totals. The industry-total figures for blue-collar and total workers in cols. 10 and 11 are taken directly from the *Censimento demografico*, and the corresponding estimates of the workers missed by the *Censimento industriale* (cols. 7 and 8) are obtained as residuals (respectively as col. 10 less cols. 1 and 4, and col. 11 less cols. 2 and 5). The industry-total horsepower figures in col. 12 are instead obtained as the sum of those the *Censimento industriale* counted, in cols. 3 and 6, and those it missed, in col. 9; these last are estimates that extrapolate (rather than merely reproduce or reallocate) the census data. All these estimates are rounded, to the nearest 50 units.

The transformation of the data in Table 1 into the estimates in Table 2 is complex, and not a little tedious; it is described in Appendix 1. In essence, the workers and horsepower in integrated shops are allocated to the various component sectors with an eye both to the differences between the total numbers of workers counted by the two censuses, and, within the industrial census, to the horsepower per worker in the integrated shops on the one hand and the corresponding specialized shops on the other. The horsepower used in the shops the industrial census missed is estimated from that in the shops it covered; since horsepower per worker was normally much higher in the large shops than in the small ones, the average in the omitted shops is extrapolated from these with an eye to the average size of omitted shops implied by the ratio of omitted owner/managers to omitted blue-collar workers.

4. The labor-cost estimates

Table 3, panel A presents the estimates of labor costs, capital costs, and value added obtained here for the various components of the engineering industry, defined as in Table 2. The estimates of labor costs are derived from the employment figures in Table 2 on the basis of standard costs per worker, allowing for the age- and gender-composition of the work force and its distribution by shop size; for simplicity, the large shops are identified directly with those counted by the *Censimento industriale*, and all the others are considered small. In the case of the railway rolling-stock and shipbuilding industries, value added is calculated directly from the available evidence, and capital costs are estimated by deducting labor costs. For the other components of the industry value added is calculated as the sum of labor costs and capital costs, built up from the factor-employment estimates in Table 2.

Labor costs are estimated as follows. In the case of large shops they are calculated on the basis of the here standard annual salary of 2,000 lire for 10% of the total work force. The actual proportion of owners, managers, and other white-collar employees was typically higher than that, at times by a considerable margin, but this presumably reflects the incidence of relatively small-scale operations whose owner-managers earned little more than blue-collar wages. The standard annual wage for adult males is estimated at 1,200 lire, for 300 days at the 4 lire per day suggested by the available data.[14] It is here applied both to actual adult male blue-collar workers, and to any male owners or managers in excess of the 10% allowed above (regardless of age and gender). Boys (to age 15) and all women and girls (letting the latter offset the former in clerical and managerial positions) are allowed half the adult male standard

[14]Direzione generale della statistica, *Annuario statistico italiano 1911*, pp. 222-224, *1913*, p. 268.

wage, or 600 lire p. a. Simplifying, the annual labor costs of large shops are calculated as 1,280 lire times the total number of workers, less 600 lire times the number of boys, girls, and women. The labor costs of small shops are similarly estimated, but without the allowance for salaried managers. Again allowing 600 lire p. a. for boys, girls, and women and 1,200 lire p. a. for the rest of the (male) work force, the annual labor costs of small shops are normally calculated as 1,200 lire times the total number of workers, less 600 lire times the number of boys, girls, and women; in rows 9 – 11, exceptionally, these figures are raised to 1,350 and (minus) 750 lire, respectively, on the presumption that adult male small-shop watchmakers, jewelers, and the like were highly skilled artisans, and earned (12.5%) more than standard wages. The total numbers of boys, girls, and women are transcribed in Table 3, panel A, col. 1; these figures are taken directly from the *Censimento demografico*, aggregating over the census categories indicated in Table 2, and again simply rounded to the nearest 50.

Table 3, panel A, rows 4 and 5 refer to the railway rolling-stock and shipbuilding industries. Since they were utterly dominated by large shops (Table 2), their employment is attributed for simplicity entirely to the latter, and their labor costs are calculated directly from the estimated industry totals and the large-shop unit labor costs noted above. For the rolling stock industry, therefore, labor costs are estimated as 1,280 lire times 48,150 workers (Table 2, row 4, col. 11), less 600 lire times 2,300 (Table 3, panel A, row 4, col. 1), for a total of 60.25 million lire (Table 3, panel A, row 4, col. 4, and zero in col. 8). For the shipbuilding industry, similarly, labor costs are estimated as 1,280 lire times 31,350 workers (Table 2, row 5, col. 11), less 600 lire times 1,350 (Table 3, panel A, row 5, col. 1), for a total of 39.32 million lire (Table 3, panel A, row 5, col. 4, and again zero in col. 8).

For the other industries, large and small shops must perforce be distinguished, and the estimating algorithm is perforce more complex. It is simplest for the industries where total large-shop employment was taken to coincide with that recorded in (relatively) specialized shops: other smithing (Tables 2 and 3, panel A, row 2), other fabricated metal (row 3), other ordinary machinery (row 7), weights and scales (row 8), precision instruments (row 9), clocks and watches (row 10), and precious-metal products (row 11). In these cases, the numbers of girls and women and of blue-collar boys are taken as the category-specific figures reported in the *Censimento industriale* (including 4.3ω in row 3 and 4.5ω in row 7); since the latter census does not separate out other boys, the figures for the latter are taken from the *Censimento demografico*, on the assumption that the males under 15 in clerical work were all in large shops. The (rounded) sums of these figures are here transcribed in Table 3, panel A, col. 2, and the small-shop figures in col. 3 are obtained as residuals (col. 1 less col. 2). In the case of other heavy equipment and machinery, the present large-shop estimate of 53,500 total workers (Table 2, row 6, col. 2) includes 48,100 total workers in (totally) specialized shops (categories 4.41, 4.43, and 4.45); considering the other 5,400 as 72% of the 7,500 in category 4.4ω, the total number of women, boys and girls in large shops is taken as all the women, girls, and blue-collar boys in categories 4.41, 4.43, and 4.45 plus 72% of those in category 4.4ω listed in the *Censimento industriale*, plus all the white-collar boys in categories 4.41, 4.43, and 4.45 listed by the *Censimento demografico*. The (rounded) sums of these figures are here transcribed in Table 3, panel A, col. 2, and the small-shop figures in col. 3 are again obtained as residuals (col. 1 less col. 2). In the case of blacksmithing, finally, the present large-shop estimate of 39,750 total workers (Table 2, row 1, col. 2) includes only 3,200 total workers in (totally) specialized shops (category 4.31); treating the residual 36,550 as 92% of the 39,850 in category 4.ω, the total number of women, boys and girls in large shops is taken as all the women, girls, and blue-collar boys in category 4.31, plus 92% of those in category 4.ω listed in the *Censimento industriale*, plus all the white-collar boys in category 4.31 listed by the *Censimento demografico*. The (rounded) sums of these figures are here transcribed in Table 3, panel A, col. 2, and the small-shop figures in col. 3 are again obtained as residuals (col. 1 less col. 2).

With the estimates of women, boys, and girls in large and small shops thus in place, the corresponding labor costs in Table 3, panel A, rows 1 – 3 and 6 – 11, cols. 4 and 8 are obtained using the algorithms described above.

5. The capital-cost and value added estimates

The railway rolling stock and shipbuilding industries were exceptionally well documented by industry-specific sources. Value added is estimated directly at 125.16 million lire in the rolling-stock industry, and 75.08 million lire in shipbuilding; as noted, it is all attributed to large shops (Table 3, panel A, rows 4 – 5, cols. 7 and 11).[15] Deducting the above estimates of labor costs equal to 60.25 and 39.32 million lire, respectively (col. 4), one obtains estimates of capital costs equal to 64.91 million lire for the rolling-stock industry, and 35.76 million lire for the shipbuilding industry (col. 5). Divided by the corresponding horsepower estimates, equal to 34,700 and 18,750, respectively (Table 2, rows 4 – 5, col. 12), these crude residuals yield estimates of capital costs per horsepower equal to 1,871 lire p. a. in the rolling-stock industry and 1,907 lire p. a. in the shipbuilding industry; and these last are within some 2% of each other. These initial ratios are here refined to distinguish labor-related and other, essentially machine- and power-related, capital costs; allowing 12.5% of labor costs to the former and obtaining the latter as a residual, machine-related capital costs work out to some (64.91 – 7.53) = 57.38 million lire in the rolling-stock industry, and (35.76 – 4.92) = 30.84 million lire in shipbuilding, or 1,654 lire per horsepower in the one and a virtually identical 1,645 lire per horsepower in the other.

For the other components of the engineering industry value added is estimated as the sum of labor costs, as estimated above, and capital costs. The capital costs of the large shops are derived from the estimates in Table 2 on the basis of capital costs per worker (again set at .125 times total labor costs) and industry-specific capital costs per horsepower extrapolated from the rolling-stock and shipbuilding industries in 1911, using interindustry relatives drawn in the main from the data for 1938 in the *Censimento i. e c.*.[16] That year was fortunately much like 1911, in the sense that metal consumption in general, and the railway rolling-stock and shipbuilding industries in particular, were setting new highs, so the relative earnings of capital should not be visibly distorted by differences in cyclical circumstances.[17]

The engineering industry is covered by the *Censimento i. e c.*, vol. 3, pp. 56-114. The census distinguishes “artisanal shops” and "industrial shops" (actually the “industrial shops” with more than 10 total workers, as the smaller “industrial” works were counted with the artisanal shops, p. 57; asymmetrically, however, a small number of the latter group had more than ten workers, p. 61); Table 1 alone reports industry-wide (employment) data, Tables 2 – 3 refer to the “artisanal” shops alone, and Tables 4 – 21 to the “industrial” shops alone (with annual data referred to 1937 for the former and 1938 for the latter, p. 57). The industry was

[15] On the derivation of these value added estimates see Ciccarelli and Fenoaltea, “Shipbuilding” and “The Rail-Guided Vehicles Industry.”

[16] Istituto centrale di statistica, *Censimento industriale e commerciale 1937-40*, 11 vols., Rome, 1939-50; briefly *Censimento i. e c.*

[17] On the time path of naval shipbuilding and railway-rolling-stock production see Ufficio storico della Marina militare, *Le navi d’Italia*, vol. 8. *Almanacco storico delle navi militari d’Italia, 1861-1975*, Rome, 1978, and Istituto centrale di statistica. *Sommario di statistiche storiche italiane, 1861-1955*, Rome, 1958, pp. 129-130.

further subdivided into no fewer than 56 activity-specific categories (78 – 133, including the here irrelevant categories 78 – 79, foundries, and 132, installation of equipment); unfortunately, as an economy measure, category-specific data were published only in Table 21 (sales), and all the other evidence was presented only for 17 subaggregates (of which one refers to categories 78 – 79, the other to 132 by itself).

Table 3, panel B transcribes the 1938 census data for the 15 subaggregates relevant here. The first (unnumbered) columns report the 1938 census codes, and the content of the corresponding subaggregate. Col. 1 transcribes the corresponding 1911 census code, as reported in panel A, with the actual or at least dominant content of the subaggregate identified from the detailed, category-specific sales data in the *Censimento i. e c.*, vol. 3, pp. 73 ff., Table 21; one notes in particular that category 133 (row 15) corresponds essentially to the armaments.industry. Cols. 2 – 6 refer to the (large) "industrial" shops: cols. 2 and 3 transcribe the (total) employment, and (installed) horsepower, reported in census Table 1, cols. 4 and 5 the wage bill, and value added, reported in census Table 15. Net (non-labor-related) capital costs per horsepower are estimated by deducting from value added the reported wage bill, a further 20% of the wage bill to allow for salaries (a ratio calculated allowing as in 1911 salaries of 200 lire per worker and a wage bill of 1,080 lire per worker less 600 lire per woman, noting from census Table 4 that 93,000 of the industry's 651,000 total workers were females), and .125 times wages and salaries together to allow for labor-related capital costs. Dividing these residuals by reported horsepower (col. 3) one obtains the per-horsepower estimates transcribed in Table 3, panel B, col. 6.

The corresponding large-shop estimates of capital costs per horsepower in 1911 (Table 3, panel A, rows 1 – 3 and 6 – 11, col. 6) are derived from these last; the procedure is again complex, and described in Appendix 2. Aggregate capital costs are then estimated by multiplying these figures by total horsepower (Table 2, col. 3), and adding .125 times total labor costs (Table 3, panel A, col. 4). The resulting estimates are transcribed in Table 3, panel A, rows 1 – 3 and 6 – 11, col. 5. Total large-shop value added (panel A, col. 7) is then obtained directly as the sum of labor and capital costs (panel A, cols. 4 and 5).[18]

For the reasons also detailed in Appendix 2, the census of 1938 appears not to permit the construction of analogous estimates of capital costs per horsepower in small shops. In the face of this obstacle, the capital costs of the small shops are here estimated, exactly like those for the large shops, as .125 times the estimated total labor cost, plus their aggregate horsepower (Table 2, cols. 6 plus 9) simply multiplied by the estimate of net capital cost per horsepower in the corresponding large shops (Table 3, panel A, col. 6). The resulting figures are transcribed in

[18] These large-shop estimates warrant three comments. The first is that the estimates of total capital costs (excluding the rolling-stock and shipbuilding industries) are sensitive to the assumed split between labor- and power-related capital costs, but not, in the aggregate, very much; replicating the above algorithm with all capital costs tied to horsepower, and none to labor, the sum of the capital costs attributed to the industries involved would fall by some 10%, from the near 116 million lire obtained here to 105 million lire, and the corresponding value added by 4%, from 293 million lire to 279. The second is that the census data point to a general rise in the horsepower-labor ratio from 1911 to 1938, inflated no doubt by the shift from horsepower in use to horsepower installed, but surely real enough; even assuming that the horsepower in use were just 60% of those installed (well under the ca. 75% ratio suggested by the metalmaking data), average horsepower per worker practically doubled, from (126.4/229.3), or ca. .55 (from Table 2, cols. 2 and 3), to .6(1,054.0/606.2), or ca. 1.04 (from Table 3, panel B, cols. 2 and 3). The third is that the census data (and the present estimates) suggest that the share of labor costs in value added was generally higher in 1911 than in 1938, averaging some 56% in 1911 (from Table 3, panel A, separately aggregating cols. 4 and 7), and just 47% in 1938 (from panel B, 1.2 times the aggregate of col. 4 divided by the aggregate of col. 5). Together, these last two considerations point to the substitution of machinery for labor as technical progress reduced the relative cost of equipment (in efficiency units).

Table 3, panel A, col. 9. As before, small-shop value added (col. 10) is obtained as the simple sum of labor costs (col. 8) and capital costs (col. 9). Aggregate value added (col. 11) is in turn the sum of the separate estimates for large shops (col. 7) and small shops (col. 10); summing finally over the elements of col. 11 one obtains the industry-wide aggregate of 827 million lire; of this total, scarcely one quarter can be traced to the well-documented shipbuilding and railway-vehicles industries.

II. THE STRUCTURE OF THE GENERAL ENGINEERING INDUSTRY IN 1911

1. Metal consumption

The concern here is with the structure of what shall be called for convenience the "general engineering" group, that is, engineering shorn of the *sui generis* precious-metal-products industry, and also of the shipbuilding and railway-vehicles industries. The latter two industries worked wood as well as metal; those considered here are by definition (almost) exclusively metal-working, and their wood-processing counterparts (such as the construction of wooden hydraulic engines) are attributed to the wood-working industry. The more fundamental difference, for present purposes, is that the shipbuilding and railway-vehicles industries are abundantly documented, so that detailed time-series estimates can be (and have been) based on direct evidence, while at the other extreme the evidence on the precious-metal-products industry is so scanty as to preclude disaggregation; the residual at hand is in between, with the components so far identified at once amenable to further disaggregation, and still so heterogeneous as to warrant the effort.

The indirect evidence of this residual production includes of course the present group's apparent consumption of semi-finished (ferrous and non-precious non-ferrous) metal, calculated here by adding net imports to estimated output, and deducting estimated direct consumption by other sectors (including construction and the utilities, as well as the shipbuilding and railway-vehicles industries).[19] Metal consumption of course constrains the industry's total product; but it is a poor index of its movements, for average value added per unit of metal is sensitive to the composition of new production, and perhaps even more to the balance between (cyclical, materials-intensive) new production and (trend-dominated, labor-intensive) maintenance. To capture the evolution of the industry's total product one must track its composition, which cannot be presumed to have varied uniformly, much less to have remained constant, over time; the path of the industry's various components must be reconstructed allowing for variations in their relative shares of the total consumption of metal. Clearly, too, the overall metal-consumption constraint is more directly binding for the component industries that consumed more metal, as even a small relative change by a large consumer may imply an impossibly large relative change by a small one, and even a large relative change by a small consumer is without practical consequence for the large one: the practical upshot is that the path of the minor consumers of metal must be estimated from independent evidence, leaving the major consumers alone constrained by the (residual) consumption of metal.

[19] This last correction, over and above the customary exclusion of rails, is particularly significant: the reductions to allow for railway chairs, rebars, I-beams, pipes, wire, and the like grow from 11% of ferrous-metals consumption net of rails in 1861 to 23% in 1913, while the net consumption of other metals adds back just 3 to 5%, without much altering the resulting time path. The derivation of these estimates cannot be described here; it is available on request.

To allow the time-series estimates to capture the evolving structure of its product the 1911 benchmark estimates for the "general engineering" group at hand distinguish thirteen separate components, only jointly (and, as noted, differentially) constrained by the total consumption of metal. In general, the present estimates distinguish three activities: maintenance, new production from metal, and also, where relevant, new production by assembling imported parts. This last is of course tracked directly by the corresponding imports; it is their strongly cyclical path that suggests they were used as components of new machinery rather than, as is common today, for replacement during maintenance.[20]

These activities are here distinguished within four industries. One is the fabricated metal ("hardware") industry, which corresponds in Tables 2 and 3, panel A, to rows 1 – 3 and 8 (this last on the above-noted presumption that it produced traditional steelyards and weights, "precision hardware" that is for present purposes simply hardware). Its new production (from metal) is here estimated as a single aggregate, its maintenance activity is instead divided into three elements, distinguishing that by blacksmiths, that by other smiths, and the residual. Another is the "precision instruments" industry, which corresponds in Tables 2 and 3, panel A, simply to row 9; again simply, it is estimated as single aggregate for new production (from metal), and a single aggregate for maintenance. A third is the "clocks and watches" industry, which corresponds in Tables 2 and 3, panel A, simply to row 10; it is subdivided into two new-production components (production from metal, and by assembling imported parts), and a single aggregate for maintenance. The fourth is the (residual) "general equipment" industry, which produced structural components and (ordinary) machinery, and corresponds in Tables 2 and 3, panel A, to rows 6 and 7 together. Its maintenance activity is again estimated as a single aggregate; its new production, by three subaggregates, of which one again refers to the assembly of imported parts, and two to production from metal, distinguishing that of truss-structure components from that of everything else (general machinery, other structural components).

In general, of course, value added per ton of metal will be higher in the new production of complex and especially precision equipment than in that of hardware, much higher still in maintenance, infinite in the mere assembly of imported parts. But it also varies significantly even within the present new-production categories, for example within hardware as between nails and needles, within residual general equipment as between pressure pipelines and handguns, even within time-pieces as between tower clocks and fine watches. The present estimates remain very crude; but they are what can be obtained with the sources so far recovered.

In outline, these benchmark estimates for 1911 are obtained as solutions to a system of equations, summarized by the 23 X 8 matrix that appears as Table 4. Thirteen rows correspond to the thirteen components to be estimated as separate time series; the further ten are subtotals and totals that are, by definition, simple sums of the others. Of the eight columns, in turn, four correspond to the variables that are to be obtained as final or intermediate estimates (respectively value added at 1911 prices, and physical product, on the one hand, and metal consumption and the work force, on the other), the other four to the coefficients that link the preceding (value added per ton of output and per worker, and metal consumption per ton of output and per worker). Some cells are by definition empty (for example, only the seven rows that correspond to the elementary new-production series

[20] In an age before cheap air freight, it would seem, firms simply did not have the now low-cost option of obtaining parts from the manufacturer as they happened to be needed. Had replacement parts been ordered as needed from the original manufacturer the machines' down-time would have been long and costly, had original spare parts been held in stock inventories would have been large and costly; the least-cost solution, it would appear, was simply to mend or remanufacture parts as needed, incurring high direct production costs but saving the even greater costs of waiting, or of keeping large inventories.

include estimates of physical output, and of the corresponding value added and metal consumption per unit), some obviously null (metal consumption in mere assembly); others are filled by specific direct estimates (for example, the industry-total work force figures, the input-output ratios, the quantities of assembled parts), or by extrapolation (about which more below). When enough cells are filled, the equations that link the cells can of course be solved for the remaining unknowns. The evidence for 1911 is as noted particularly rich; but as will be seen forthwith even the estimates for that year needs make use of the available information pertaining to the earlier census-year benchmarks.[21]

2. Maintenance and new production: the approach

For the broad aggregates in Table 4, rows 6 (fabricated metal), 12 (general equipment), 15 (precision instruments), and 20 (clocks and watches), some estimates are at this point ready-made. The value added estimates in col. 1 simply transcribe from Table 3, panel A, col. 11 the sum of rows 1 – 3 and 8 (fabricated metal, into row 6), the sum of rows 6 – 7 (general equipment, into row 12), row 9 (precision instruments, into row 15), and row 10 (clocks and watches, into row 20); the sum of these partial figures is the industry-group total in row 23. The analogous labor-force estimates in col. 4 are similarly obtained from the same rows of Table 2, col. 11; and the corresponding estimates of average value added per worker in 1911 (Table 4, rows 6, 12, 15, 20 and 23, col. 6) are then obtained directly as the ratio of total value added (col. 1) to total workers (col. 4).

The estimates of value added and metal consumption per ton of output (rows 1, 7 – 9, 13, and 16 – 17, respectively cols. 5 and 7) are derived from independent evidence, as described in Appendix 3 below.

The estimate of the group's aggregate metal consumption (801,000 tons) is transcribed in Table 4, row 23, col. 3; divided by the aggregate labor force (col. 4), it yields an average just over two tons per man. This figure is well above those for the earlier census benchmarks, which grow monotonically from .54 tons per worker in (indifferent) 1871 to .80 in (prosperous) 1881, and 1.08 in (depressed?) 1900, but still far below the values in the middle of the distributions generated by the Grioni sample documented in Appendix Table 1, at least for the larger of the industries at hand (fabricated metal, heavy engineering excluding road vehicles).[22] There is no reason to dismiss Grioni's micro-data, even if the metal consumption per worker they imply is high next to the overall average calculated for 1911; and if one accepts them the inescapable conclusion is the obvious one, to wit, that the discrepancy at hand is due first and foremost to the fact that the 1911 census includes, and Grioni's sample essentially excludes, large numbers of small-shop workers and artisans engaged in maintenance, with a relatively low per-capita consumption of metal.[23]

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[21] The earlier census-year benchmarks refer to 1871 and 1881 (when the census was taken at the end of the year, and to 1900 (marked by a peak in metal consumption, suggesting that the census taken very early in 1901 reflects the results of that prosperity better than it does those of the subsequent crisis); no census was taken in 1891, and the 1861 census lacked a suitable disaggregation of the labor force.

[22] U. Grioni, *Annuario della industria mineraria (per i minerali metalliferi), metallurgica, e meccanica in Italia. Anno 1, 1913/14*, 2 vols., Milan, 1914. The sample and the derivation of Appendix Table 1 are described in Appendix 4. The description of the derivation of the (pre-1911) census-benchmark labor force estimates is available on request.

[23] The sample figures refer to output weight per blue-collar worker rather than input weight per total worker, but the differences in the numerator and the denominator tend to offset each other; moreover,

The share of maintenance in total employment and value added can only be estimated; but the logical problem is straightforward. Ignoring its internal subdivisions, the industry is divided into a new-production sector, and a maintenance sector; aggregate value added, metal consumption, and employment are given, in 1911, as are value added and metal consumption per unit of output. The lower the share of aggregate (employment and) value added attributed to maintenance in 1911, the higher value added, and therefore metal consumption, in new production, and the lower, therefore the residual metal consumption available for maintenance, overall and per maintenance worker, in 1911; since the latter consumption must be positive, the share of maintenance in aggregate value added in 1911 has an obvious lower bound. The higher the share of aggregate value added (and employment) attributed to maintenance in 1911, conversely, the higher the residual metal consumption available for maintenance, overall and per maintenance worker, again in 1911. But as one goes back in time, aggregate maintenance is indexed directly by independent evidence, and 1911-price value added, employment, and metal consumption in maintenance are correspondingly determined. At the earlier benchmarks, these estimates yield as residuals the labor force and metal consumption in new production, and the corresponding metal consumption per worker (including unemployed workers, but as noted the share of the latter was plausibly small in 1871, and negligible, as in 1911, in 1881). At the early benchmarks, average metal consumption per worker is relatively low; the average in maintenance varies directly with that calculated for 1911 (as the activity-specific figures are constant, and the average varies only because their relative weights vary over time), and the higher it is, the lower is the implied average in new production. But metal consumption per worker must always have been many times higher in new production than in maintenance: a reasonable ratio between the two at the 1871 benchmark requires that estimated metal consumption per worker be sufficiently low in 1911, that is, on the logic outlined above, that the share of (employment and) value added attributed to maintenance in 1911 also be sufficiently low. In short, the share of maintenance in 1911 is bounded from below by the implied metal consumption in maintenance in 1911 itself, and from above by the implied ratio of metal production per worker in new production to that in maintenance decades earlier; and the margin between these two bounds turns out to be pleasingly narrow.

In practice, of course, the internal subdivisions of the industry cannot be ignored, and in Table 4 the estimates of value added and employment in maintenance are to be obtained for rows 2 – 4, 11, 14, and 19. They are here obtained on the assumption that maintenance was everywhere a small-shop handicraft activity performed with minimal tooling; value added per worker is estimated as the average small-shop wage (the ratio of Table 3, col. 8, to the sum of Table 2, cols. 5 and 8, with rows 3 and 8 there combined to obtain row 4 here, and rows 6 and 7 there combined to obtain row 11 here; the implicit assumption that that the share of women, boys, and girls was the same whether the small shop engaged in maintenance or new production is inevitable, given the typical preponderance of maintenance activity among the small shops), times 1.125 to allow for labor-related capital costs (as above), times a further scale factor *f* that captures the residual differences between maintenance and new production (for example, a differential use of hand tools; this parameter is presumably near 1.00, but not necessarily above it). The industry-specific share of maintenance is then estimated on the assumption that the large

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while the Grioni sample firms were above average in both size and power-intensity, within that sample neither variable is significantly correlated with product weight per worker. In the later 1930s, admittedly, the large engineering shops of the day consumed some 2 million tons of metal, or just over 3 tons for each of their 600,000-odd workers (*Censimento i. e c.*, vol. 3, p. 72, and above, Table 3): a relatively low average apparently in line with the above pre-war figures and inconsistent with the Grioni sample, on reflection entirely consistent with the latter if one allows for the great increase in automobile and aircraft production.

shops covered by the industrial census were devoted entirely to new production, with a "high" value added per worker, and that the remaining (small) shops, with a "middling" value added per worker, were a mix of new-production shops with a "high" value added per worker equal to that in the large shops, and of maintenance shops with the estimated "low" value added per worker; given the way the employment and value added estimates were constructed (above, part I), the algorithm in effect uses the shops' relative size and power-intensity to discriminate between maintenance and new production. With the "middling" small-shop value added per worker thus defined as a weighted average of the "high" figure in new production and the "low" one in maintenance, the higher the "low" figure, the greater its weight in the "middling" one; and given average wages, that "low" (maintenance) figure varies directly with the above-mentioned scale factor *f*, for as *f* rises so do the estimated shares of (small-shop and total) value added and employment absorbed by maintenance. On the logic outlined above, as the maintenance share of total value added (and employment) increases, the overall metal-consumption constraint is more readily met without pushing other estimates beyond their reasonable limits; by (reasonable) assumption, however, the maintenance share can nowhere exceed 100% of small-shop (value added and) employment. To keep all the industries at hand below the latter limit, *f* is here set equal to 1.025; the resulting estimates of value added per worker in maintenance in 1911 are transcribed in Table 4, rows 2 – 4, 11, 14, and 19, col. 6.

3. Maintenance and new production: fabricated metal, precision instruments, clocks and watches

In blacksmithing, therefore, average value added per worker in large (industrial-census) shops is estimated as the ratio of value added (69.68 million lire, Table 3, panel A, row 1, col. 7) to employment (39,750 workers, Table 2, row 1, col. 2), or 1,752.96 lire; average value added per worker in other shops is similarly estimated (as the ratio of 146.98 million lire, Table 3, panel A, row 1, col. 10 to 110,850 workers, Table 2, row 1, col. 5 plus col. 8), at 1,325.94 lire. Setting $1{,}325.94 = a1{,}292 + (1 - a)1{,}752.96$ and solving, *a* (the share of maintenance in total other-shop employment) works out to just over 92.6%. In Table 4, row 2, therefore, the maintenance-employment estimate in col. 4 equals 102,690 workers (*a* times 110,850), and the corresponding value added estimate in col. 1 (132.68 million lire) is simply the product of cols. 4 and 6; with *f* = 1.00, and not 1,292 but 1,260 lire per worker in col. 6, for example, the estimates in cols. 1 and 4 would be 120.99 million lire and 96,020 workers, respectively.

The corresponding estimates of value added and employment in other fabricated-metal maintenance in Table 4, rows 3 and 4, cols. 1 and 4 are obtained exactly like those in row 2, using the corresponding estimates in Tables 2 and 3, panel A (respectively rows 2, and 3 plus 8, there for rows 3 and 4 here). The calculated maintenance shares of small-shop employment equal some 90.3% for other smiths (row 3), near the figure obtained for blacksmiths, and 31.8% for the residual; the disparity between these figures suggests on the one hand that some hardware received no maintenance at all (thus nails, tin cans, and so on), and on the other that the maintenance workers were mostly general-purpose smiths (and of course knife-grinders, who account for about half of those attributed to the residual in row 3). Table 4, row 5, cols. 1 and 4 report the estimates of aggregate value added and employment in the maintenance of fabricated metal, obtained as the sum of the partial estimates in rows 2 – 4. With these last in place, the estimates of value added and employment in the new production of fabricated metal in Table 4, row 1, cols. 1 and 4 are obtained as residuals, deducting the maintenance totals in row 5 from the industry totals in row 6. The rest of the new-production estimates in row 1 are immediately obtained: output (col. 2) as the ratio of total value added (col. 1) to value added per unit (col. 5); total metal consumption (col. 3) as output (col. 2) times the input-output ratio (col. 7); value added per worker, as the ratio of total value added (col. 1) to employment (col. 4); and metal consumption per worker (col. 8), as the ratio of total metal consumption (col. 3) to employment (col. 4). This last figure works out to 5.49 tons per worker, or 4.07 tons of output per worker, and perhaps 4.42 tons of output per blue-collar worker (from the large-shop estimates in Table 2, rows 1 – 3 and 8, cols. 1 – 2): below the median, but well above the fortieth percentile, of the distribution obtained from the Grioni sample (Appendix Table 1, panel A, col. 7).

The derivation of the estimates for the precision-instruments industry is similarly straightforward. The estimates of value added and employment in maintenance in Table 4, row 14, cols. 1 and 4 are obtained exactly like those in row 2, using the corresponding estimates in row 9 of Tables 2 and 3, panel A; the calculated maintenance shares of small-shop activity equals 53.2%. The estimates of value added and employment in new production in Table 4, row 13, cols. 1 and 4 are then obtained exactly like those in row 1, by deducting the maintenance figures (here simply row 14) from the corresponding industry totals (row 15); and these yield the remaining new-production estimates in row 13, through the same simple calculations as were used to complete row 1. Again proceeding as above, one deduces from the resulting estimate of metal consumption per worker (col. 8) that the implied output per blue-collar worker was something under two quintals per year, a figure well within the broad range defined by the few relevant figures in Grioni's sample (Appendix Table 1, panel E, col. 7).

In the case of watchmaking, the algorithm used above yields a "low" value added per worker of 1,535 lire, whence a low-value added small-shop employment share of no less than 99.5%, or 7,760 workers with a value added of 11.91 million lire; but in watchmaking these low-value-added handicraft activities presumably include the assembly of imported parts. The above estimate of 1,535 lire per worker thus appears in Table 4, col. 6, both in row 16 (assembly) and in row 19 (maintenance). Mere assembly (row 16) is allowed 8,000 lire per ton (col. 5) and 160 tons of output (from the import data), whence a value added of 1.28 million lire (Table 4, row 16, col. 1), and, given value added per worker (col. 6), 830 workers (col. 4). Since the large shops employed just 900 blue-collar workers (Table 2, row 10, col. 1), and as noted in Appendix 3 the Borletti works alone over 600, these assembly workers were at least preponderantly in small, artisanal shops. For simplicity, and ignoring possible exceptions, all are here attributed to such shops.[24] Maintenance is accordingly attributed the residual "low value added per worker" value added, or (11.91 – 1.28) = 10.63 million lire (row 19, col. 1), and employment, or (7,760 – 830) = 6,930 workers (row 19, col. 4). The estimates of value added and employment in new production from metal in Table 4, row 17, cols. 1 and 4 are of course the industry totals (row 20) less those attributed to assembly and maintenance together (11.91 million lire and 7,760 workers, separated into assembly in row 16 and maintenance in row 19); and these yield the remaining estimates in row 17, through the usual simple calculations. Total value added and employment in new production (row 18, cols. 1 and 4) are of course the simple sums of the separate estimates for assembly (row 16) and production from metal (row 17).

4. Maintenance and new production: general equipment

The derivation of the estimates for the general equipment industry is the most complex. Here, the application of the usual algorithm to the relevant data in Tables 2 and 3, panel A (summing over rows 6 and 7) yields an estimated "low" value added per worker of 1,331 lire; this figure is attributed to maintenance (Table 4, row 11, col. 6). The difficulties stem from the

[24] On the exceptions see Direzione generale della statistica, *Statistica industriale. Riassunto delle condizioni industriali del Regno*, henceforth *Riassunto industriale*, vol. 1, Rome, 1906, p. 58.

distinctions within new production. As in watchmaking, new production includes the assembly of imported parts; but whereas assembling watch mechanisms was plausibly the work of artisans, the assembly of machines that were made of, or incorporated, imported parts was presumably the work of (large) new-production shops. Value added per worker is accordingly estimated as average large-shop labor costs per worker (Table 3, panel A, row 6 plus row 7, col. 4, divided by Table 2, row 6 plus row 7, col. 2), again times 1.125 to allow for labor-related capital costs (as above), and again times the scale factor $f = 1.025$, or 1,387 lire per worker (Table 4 , row 7, col. 6). Assembly is further allowed 14,180 tons of output (again from the import data) and 300 lire of value added per ton (col. 5, from Appendix 3), whence a total value added of 4.25 million lire (col. 1), and, given value added per worker (col. 6), an estimated employment of 3,060 workers (col. 4). With assembly assigned to large shops, the latter are attributed, for their new production from metal, a value added of 167.55 million lire (the 171.8 in Table 3, panel A, rows 6 plus 7, col. 7, less that in assembly) and 75,740 workers (the 78,800 in Table 2, rows 6 plus 7, col. 2, less those in assembly), or a value added per worker just over 2,212 lire. Again taking the small shops' value added per man (Table 3, panel A, rows 6 plus 7, col. 10, divided by Table 2, rows 6 plus 7, col. 5, or just over 1,587 lire), as a weighted sum of the large-shop average in new production from metal and the average in maintenance (1,331 lire), maintenance is attributed just under 71% of total small-shop employment (Table 2, rows 6 plus 7, col. 7), or 24,690 workers (Table 4 , row 11, col. 4) and, at a value added of 1,331 lire each (col. 6), a total value added of 32.86 million lire (col. 1).

Deducting the maintenance value added and employment estimates in Table 4, row 11, cols. 1 and 4 from the industry totals in row 12 yields the new-production totals in row 10; further deducting those attributed to assembly (row 7), one is left with a value added of 189.92 million lire, and 85,850 workers, for general-equipment new production from metal, that is, for the manufacture of truss-structure components on the one hand (row 8) and the residual on the other (row 9). The output of truss-structure components is estimated at 41,770 tons (row 8, col. 2), again from independent evidence (in fact an early data point, extrapolated by suitably weighted construction).[25] It implies a value added of 14.62 million lire (row 8, col. 1, from cols. 2 and 5), and a metal consumption of 50,120 tons (col. 3, from cols. 2 and 7). The residual is accordingly left with the remaining 175.30 million lire of value added (row 9, col. 1), which in turn implies an output of 194,780 tons (col. 2, from cols. 1 and 5) and a metal consumption of 234,480 tons (col. 3, from cols. 2 and 7), whence a total metal consumption in new production of 293,600 tons (row 10, col. 3, from rows 7 – 9). All that remains is the allocation to truss-structure components and other production from metal of the 85,850 workers assigned to the two together; and given the other estimates the work-force figures in col. 4 obviously determine value added per worker (col. 6, obtained as col. 1/col. 4) and metal consumption per worker (col. 8, obtained as col. 3/col. 4). The compatible estimates in rows 8 and 9, cols. 4, 6, and 8 vary inversely to each other; and with the manufacture of components in row 8 a much smaller industry than the residual in row 9, a given relative change in row 9 will involve a much larger relative change in row 8, and vice versa. In general, one would expect value added and metal consumption per worker to be significantly higher in truss-structure components than in the residual, as the former involved only the (capital-intensive) fabrication of the metal, while the latter typically included the (labor-intensive) assembly of the resulting pieces. The most useful data here seem to be the output weights per blue-collar worker in the Grioni sample (Appendix Table 1, col. 7); median values are there near 9.3 tons per man in structures (panel B), and 3.0 in general machinery (panels C – E, merged and purged of six low precision-equipment figures). Allowing for the slightly different input-output coefficients, these output tonnages point to an input tonnage per man in structural components 3.0 times that in general machinery; metal

[25] Once again, the description of the procedure cannot be provided here, but is available on request.

consumption is here set at 9.09 tons in structural components (row 8, col. 8), whence a corresponding work force of 5,510 (row 8, col. 4, obtained as col. 3/col. 8), leaving to the residual industry 80,340 workers (row 9, col. 4) with a metal consumption of 3.03 tons per worker (col. 8, obtained as col. 3/col. 4). The resulting estimates of value added per worker are obtained as the ratio of col. 1 to col. 4; the figure obtained for (capital-intensive) structural components (row 8, col. 6) is over 20% higher than that in the residual (row 9, col. 6) and some 90% higher than that in (labor-intensive) assembly (row 7, col. 6), and these proportions too do not appear unreasonable.

5. Maintenance and new production: metal consumption

Table 4, rows 21 and 22 transcribe the new-production and maintenance totals. New-production value added, metal consumption, and employment (row 21, cols. 1, 3, and 4) are simply the sums of the industry figures in rows 1, 10, 13, and 18, and these yield the per-worker averages in cols. 6 and 8. Maintenance value added and employment (row 22, cols. 1 and 4) are similar sums of industry figures (rows 5, 11, 14, and 19); metal consumption (col. 3) is obtained as a residual (row 23 minus row 21), and the per-worker averages are again obtained from the obvious ratios. Interestingly, maintenance appears to account for 40% of value added, and half the work force, but a trivial share of metal consumption (ca. 1%, as calculated, equivalent to perhaps half a quintal per worker; but this an obviously imprecise residual).

The last step is the allocation of estimated total metal consumption in maintenance (row 22, col. 3) to its components: maintenance by blacksmiths (row 2) and by other smiths (row 3), of other fabricated metal (row 4), of general equipment (row 11), of precision instruments (row 14), and of clocks and watches (row 19). This allocation is in proportion to the employment estimates in col. 4, suitable weighted. Blacksmiths (row 2) and other fabricated-metal workers (row 4) are allowed a unit weight; since iron pieces are typically far heavier, for any given size and shape, than pieces of copper or other metal, even if, conversely, more often reforged than patched, the employment of coppersmiths, tinsmiths, and the like (row 3) is discounted by four fifths. Because the maintenance of precision equipment seems in the main to result from maladjustment rather than breakage, and the parts involved are typically small, the corresponding employment figures (rows 14 and 19) are discounted by seven eighths. To reabsorb the resulting rounding error, finally, the largest metal-consumption estimate, that for blacksmiths, is reduced by 10 tons.

In general equipment, on the other hand, maintenance was in essence the maintenance of machinery, as the maintenance even of metal structures is attributed to the construction industry; and the manufacturing of replacement parts for machines would seem to consume far more metal per worker than repairs by blacksmiths, which would appear typically to involve reforging, with no more than minor patching. General-equipment maintenance workers (row 11) are accordingly attributed a treble weight. Dividing the resulting metal consumption (row 11, col. 3) by the corresponding input-output ratio (row 9, col. 7), the implied production of replacement parts works out to some 3,000 tons. Value added in the maintenance of general equipment is calculated at near 33 million lire (row 11, col. 1); with a value added per ton of parts of 900 to 1,200 lire (1.5 to 2.0 times the 600 lire allowed above for parts of new machines, to allow for the relative inefficiency of one-off production), the share of that value added represented by the manufacture of replacement parts works out in turn to some 8 to 11%, which appears reasonable enough.

The metal-consumption (subtotals and) totals in rows 5 – 6, 12, 15, and 20, col. 3, are then obtained as the obvious sums; the corresponding per-worker estimates in col. 8 are in turn obtained as the ratios of the corresponding metal-consumption figures in col. 3 and employment estimates in col. 4.

The critical validation of the proposed solution to the equations summarized by Table 4 is to be found in the lower right-hand corner, in the estimates of metal consumption per worker in new production on the one hand and maintenance on the other (rows 21 and 22, col. 8; the overall average in row 23 is for present purposes a given). These work here essentially as micrometers, leveraging small variations into observably large ones: given the data, given the estimated coefficients, they tightly constrain the estimated breakdown of the aggregate into new production on the one hand and maintenance on the other.

The lower bound to the share of maintenance is internal to the year 1911: the estimated metal consumption per worker is low, if the maintenance share of value added is reduced at all, it quickly becomes negative.

The evidence for 1911 provides no corresponding upper bound: metal consumption per worker in new production is near ninety times that in maintenance, the estimate for the latter could be multiplied many times over without becoming intrinsically implausible. But as one goes back in time metal consumption per maintenance worker is affected only by the changing mix of the stocks maintained, and varies little; the precipitous decline in the overall average noted above appears perforce in metal consumption per new-production worker, and if the maintenance share in 1911 is raised at all the implied ratio of metal consumption per new-production worker to metal consumption per maintenance worker in 1871 quickly becomes too close to one to be credible.[26]

III. ON METHOD

The above reconstruction of the engineering industry's product in 1911 prompts some concluding considerations on method: specifically on the non-independence of cross-section estimates from the related time-series evidence, more generally on our approach to the sources.

Time series can of course be anchored by cross-sections, cross-sections built up by juxtaposing elements of time series; that much is obvious, and need not detain us here. The less obvious point is that cross-sections may well require supporting time series to be (properly) built up at all; the reason is of course that the evidence we have for the year in question is often ambiguous, and the related time series help reduce that ambiguity.

Various such occurrences have been noted above, and here need only be recalled. An obvious example concerns the proper interpretation of the demographic-census labor force data, notably as a guide to the employment levels that we need to estimate. As seen above, the intersectoral mobility of workers (and in particular the unskilled) means that the reported labor force can even fall short of actual employment; but even in more normal cases, when such overfull employment can be ruled out, the proper allowance for unemployment cannot be pinned down from the cross-section evidence alone. Only the production time series can tell us whether the industry was experiencing normal growth, or in the throes of a temporary or permanent collapse: whether the appropriate allowance for unemployment is a "frictional" few percent, an altogether higher "cyclical" percentage, or an even higher "technological" one, as when a once prosperous industry has suddenly become obsolete and is destined shortly to disappear altogether.

[26] The description of the extrapolation that yields the estimates at the earlier census-year benchmarks cannot be provided here either, but is again available on request.

Another example concerns goods rather than labor. The trade data record imports of machine parts, but there is nothing in the source to tell us whether these were used for maintenance or for new production. The use we make of them depends critically on our understanding of their actual destination; and as seen above only the behavior of the related time series allows us reasonably to infer it.

The most dramatic example comes of course from the solution to the system of equations that underlie Table 4. As noted, the evidence internal to the year 1911 limits the likely share of maintenance in total value added only from below; the upper bound begins to become stringent only decades earlier, and a well-constrained estimate for 1911 can only be inferred by going sufficiently far back in time.

But there is more. The sources must be vetted, one must understand what they actually contain, quite apart from what they claim. An inexperienced scholar building a cross-section estimate of Italian industrial production in 1911 will naturally borrow the figures on the production of quarry and non-metallic mineral products reported for that year by the Corpo delle miniere: without a second thought.[27] But second thoughts are very much in order: the construction of the related time series at the level of the individual mining district reveals that those production data changed very little from year to year, and leads one finally to discover that the Corpo delle miniere last measured such production in 1901. The figures published in the subsequent years simply repeated the latest they had, those for 1901 with no more than occasional minor updates; by 1911 they were essentially a decade old, and entirely missed the effects of the intervening boom in construction.[28]

Nor is that all. The reports of the Corpo delle miniere are among the richest sources of annual production figures (on the mining industries, and the further processing of their products), in an admittedly bleak landscape. The engineers who filed those reports were a small number of men, with their occasional idiosyncracies; a reconstruction of the personnel series, of who served where and when, helped clarify some apparent discontinuities in the reported production figures.[29]

The more general point, which is here amply documented, is that "the data" in the sources are not to be taken at face value: they are constructs, the product of particular interests, methods, and mind-sets; to be used at all sensibly, they must be deconstructed.

APPENDIX 1: ESTIMATED EMPLOYMENT OF LABOR AND HORSEPOWER

The non-specialized-shop labor and horsepower included by the *Censimento industriale* in the mixed categories and here allocated to the various components of the engineering industry include all of those in the narrow categories 4.3ω, 4.4ω, and 4.5ω, which must of course be retained within the higher-level group (respectively 4.3, 4.4, 4.5), all of category 4.ω2 (which straddles those three groups), and only part of those in category 4.ω1 (which includes metalmaking as well as engineering) and again of the broader categories ω.31 and ω.71 (which straddle category 4 and 3 or 5). Allowing metalmaking and engineering together all the workers and horsepower in category 4.ω1 and half of those in categories ω.31 and ω.71, one

[27] Corpo delle miniere, *Rivista del servizio minerario 1911* (annual).

[28] The Corpo delle miniere did not in fact hide this; but neither did they attach a warning to that effect directly to the reported production figures.

[29] S. Fenoaltea, *Italian Industrial Production, 1861-1913: A Statistical Reconstruction*, in progress.

obtains totals of 33,279 blue-collar workers, 35,664 total workers, and 31,579 horsepower in large shops and 730 blue-collar workers, 1,298 total workers, and 385 horsepower in small shops, or, in all, 34,009 blue-collar workers, 36,962 total workers, and 31,964 horsepower; deducting the 4,500 plus 1,600 blue-collar workers, 5,000 plus 1,900 total workers, and 14,700 plus 1,500 horsepower assigned above to ferrous and non-ferrous metal production (categories 4.1 and 4.2, on large and small shops together), one obtains residuals for the engineering industry of 27,909 blue-collar workers (ca. 82.1% of the total for metalmaking and engineering together), 30,062 total workers (ca. 81.3%), and 15,764 horsepower (ca. 49.3%). Applying for simplicity these percentage shares to the separate figures for large shops and small shops, one obtains engineering-industry estimates of 27,310 blue-collar workers, 29,006 total workers, and 15,574 horsepower in large shops, and 599 blue-collar workers, 1,056 total workers, and 190 horsepower in small shops. Adding to these the (engineering-industry) workers and horsepower in category 4.ω2, finally, one obtains engineering-industry totals in categories 4.ω, ω.31, and ω.71 that round to 37,450 blue-collar workers, 39,950 total workers, and 20,800 horsepower in large shops, and 2,200 blue-collar workers, 4,450 total workers, and 500 horsepower in small shops.

The allocation of these begins with the elements of category 4.4, for which the *Censimento demografico* reports no artisans, and the coverage of the *Censimento industriale* is in principle complete. In Table 2, rows 4 and 5 refer to categories 4.42 (railway vehicles) and 4.44 (shipbuilding); since (specialized) small-shop employment was there exiguous, the workers not in the *Censimento industriale* specialized shops are all attributed to large shops. The estimated *Censimento industriale* figures for blue-collar and total workers and horsepower in small shops (cols. 4 – 6) accordingly reproduce, merely rounded, the industrial-census data for specialized small shops; the estimated figures for large-shop blue-collar and total workers are simply the (rounded) totals in the *Censimento demografico*, less those attributed to small shops. The corresponding horsepower estimates in col. 3 are in turn obtained as the estimated number of blue-collar workers (col. 1) times the ratio of horsepower to blue-collar workers in specialized large shops (from Table 1, so that the large shops in category 4.42, for example, are attributed 43,700 times .753, or, rounded, 32,900, row 4, col. 3). Absent omitted operations cols. 7 – 9 are all zero, and the totals in col. 10 – 12 correspond to the sums of cols. 1 and 4, 2 and 5, and 3 and 6, respectively; these of course return in cols. 10 – 11 the (rounded) blue-collar and total-worker figures in the demographic census.

Row 6 refers to the rest of category 4.4. The small-shop figures needs include, in addition to the sums of the specialized small-shop data for categories 4.41, 4.43, and 4.45, all those for non-specialized small shops in category 4.4ω, as none of these were attributed to categories 4.42 or 4.44; one notes that these non-specialized small shops employed just .11 horsepower per total worker, much like those in 4.43 (bicycles, automobiles), and far less than the others. The residual workers counted by the demographic census in categories 4.41, 4.43, and 4.45 but not included by the industrial census in the specialized large shops of those same categories, or in the small shops of those categories and category 4.4ω together, number 4,829 blue-collar and 5,388 total workers; and their ratio suggests that they were essentially in large shops. The small-shop figures in cols. 4 – 6 are therefore the simple sums of categories 4.41, 4.43, 4.45, and 4.4ω, and the estimated numbers of blue-collar and total workers in large shops in cols. 1 and 2 are all the other workers counted by the demographic census in 4.41, 4.43, and 4.45 (col. 10 less col. 4 and col. 11 less col. 5, respectively). As before, the large-shop horsepower estimates in col. 3 are obtained as the estimated number of blue-collar workers (col. 1) times the ratio of horsepower to blue-collar workers in specialized large shops (48,150 times .574, rounded). Again as before, absent omitted operations cols. 7 – 9 are all zero, and the totals in col. 10 – 12 correspond to the sums of cols. 1 and 4, 2 and 5, and 3 and 6, respectively.

The sums of the present estimates for small shops (cols. 4 – 6) in rows 4 – 6 return, by construction and within rounding error, the industrial-census totals for category 4.4. The sums of the corresponding estimates for large shops (cols. 1 – 3) instead exceed those totals by some 2,550 blue-collar and 3,400 total workers, and 2,000 horsepower. Of the engineering-industry components of categories 4.ω, ω.31, and ω.71 estimated above, therefore, there remain for categories 4.3 and 4.5 some 34,900 blue-collar workers, 36,550 total workers, and 18,800 horsepower in large shops, and (as before) 2,200 blue-collar workers, 4,450 total workers, and 500 horsepower in small shops.

The components of category 4.5 are estimated next. This group is divided into five components, which refer respectively to (ordinary) equipment and machinery, (ordinary) weights and scales, precision (optical, scientific, and musical) instruments, clocks and watches, and precious-metal work. The first of these (Table 2, row 7) covers categories 4.54, 4.55, 4.57, and 4.58; in these categories, as in all of category 4.4, the *Censimento demografico* reports no artisans. Category 4.5ω includes only small numbers; they are attributed entirely to this first group, on the presumption (or simplifying assumption) that specialization was altogether more likely among the manufacturers of precision equipment and precious-metal products (and even within these last, judging from the very different power-intensities of the large shops in categories 4.59 and 4.510). Summing over the categories attributed to this group, the *Censimento demografico* reports some 28,000 blue-collar and 33,700 total workers, as against 26,100 and 30,700, respectively, in the *Censimento industriale*. The differences equal 1,900 blue-collar and 3,000 total workers, for a ratio of 1.58 total workers per (hired) blue-collar worker, against 1.11 in specialized large shops and 1.67 in specialized small shops, suggesting that these workers were overwhelmingly in small shops. In consequence, the large-shop estimates in Table 2, row 7, cols. 1 – 3 are the (rounded) simple sums of the industrial-census specialized-shop data for the five categories at hand. The small-shop blue-collar and total worker estimates in cols. 4 and 5 are the demographic-census totals in cols. 10 and 11 less the large-shops figures in cols. 1 and 2, equal to the industrial-census specialized-small-shop figures (respectively 3,250 and 5,400) plus the differences between the census totals (1,900 and 3,000, respectively, as noted). The small-shop horsepower estimate in col. 6 (1,300) is the rounded product of the total number of small-shop workers (col. 5) and the industrial-census specialized-small-shop ratio of horsepower to total workers (.153, from Table 1). Cols. 7 – 9 are all zero, as for category 4.4, and col. 12 is the simple sum of cols. 3 and 6.

Table 2, rows 8 – 11 cover the other four components of category 4.5; these refer respectively to weights and scales (4.52), precision instruments (4.51, 4.56), clocks and watches (4.53), and precious-metal work (4.59, 4.510). Given the presumption of specialization in all the shops concerned, the large- and small-shop estimates in cols. 1 – 3 and 4 – 6, respectively, simply round the appropriate (sums of the) industrial-census data, and the estimates of the workers missed by the *Censimento industriale* are obtained as residuals (col. 7 as col. 10 less cols. 1 and 4, and col. 8 as col. 11 less cols. 2 and 5). The estimates of total horsepower in col. 12 are instead the simple sums of the census-shop figures in cols. 3 and 6, and the estimates of the horsepower missed by the industrial census (col. 9); the latter are derived, rather tentatively, on the assumption that both power-intensity and the hired (blue-collar) share of the total work force increased systematically with shop size.

Using the unrounded underlying data in Table 1 (aggregating as necessary over the appropriate categories), one obtains for weights and scales (row 8) .88 blue-collar workers and .18 horsepower per (total) worker in industrial-census large shops, and .57 blue-collar workers and .042 horsepower per worker in industrial-census small shops; for precision instruments (row 9), respectively .84 and .31 in the large shops, and .63 and .13 in the small ones; for clocks and watches (row 10), respectively .89 and .35 in the large shops, and .40 and .017 in the small ones; in precious-metal products (row 11), respectively .88 and .12 in the large shops, and .58

and .033 in the small ones. In the omitted shops, using the rounded estimates in Table 2, cols.7 and 8, the blue-collar share of the work force works out to .64 in weights and scales (row 8), .67 in precision instruments (row 9), .38 in clocks and watches (row 10), and .55 in precious-metal products (row 11).

In precision instruments (row 9), as is obvious from Table 2, cols. 4 – 5 and 7 – 8, the blue-collar share of the work force in omitted shops is within rounding error of that of the census small shops; the omitted shops' horsepower is accordingly estimated as their work force (col. 8) times the census-small-shop horsepower per worker indicated above (.13, with the result again rounded to the nearest 50). In clocks and watches (row 10) and in precious-metal products (row 11), the blue-collar share of the work force in omitted shops is marginally lower than that of the census small shops, and somewhat more so in the former industry than in the latter; the omitted shops' horsepower is here estimated as their work force (col. 8) times the census-small-shop horsepower per worker, simply rounded down (from .017 to .015 in the case of clock and watches, from .033 to .030 in that of precious-metal products, with the results again rounded to the nearest 50). In weights and scales (row 8), finally, the blue-collar share of the work force of omitted shops (.64) is perceptibly higher than that of the census small shops (.57), though still well below that of the census large shops (.88). Taking the first of these figures as a weighted average of the latter two, and applying those weights (.77 and .23, respectively) to the corresponding horsepower per worker (.042 and .18, respectively), the omitted shops are here attributed .074 horsepower per worker, for a rounded total of 50 (Table 2, col. 9).

Table 2, rows 1 – 3 cover category 4.3, here disaggregated to distinguish only blacksmithing (4.31), other smithing (4.32), and other metal fabrication (4.33 – 4.3<u>11</u>). Since smithing is by nature general-purpose and not specialized by product, the industrial-census workers and horsepower in 4.3ω are here attributed directly to the other activities; the estimates in cols. 1 – 3 and 4 – 6 are accordingly the corresponding figures in Table 1 for categories 4.31 (to line 1), 4.32 (to line 2), and 4.3 net of the preceding (to line 3), augmented by the corresponding elements of the engineering-industry components of categories 4.ω, ω.31, and ω.71. Of these last, as estimated above, category 4.5 was allowed no workers and horsepower in large shops, and just 1,900 blue-collar and 3,000 total workers, and (rounding) 450 horsepower, in small shops; category 4.3 is thus left to absorb all the 34,900 blue-collar workers, 36,550 total workers, and 18,800 horsepower in large shops allowed earlier for categories 4.3 and 4.5 together, and the remaining 300 blue-collar workers, 1,450 total workers, and 50 horsepower in small shops. These small-integrated-shop residuals are themselves small, and accordingly subject to considerable relative error; by the same token, however, their misallocation introduces only small relative errors in the final estimates. Taking them at face value, for what they may be worth, they point to a very low ratio of horsepower to workers (ca. .03). Next to the detailed data in Table 1, that ratio appears to be an order of magnitude lower than those observed in small non-smithing works, near half that in small blacksmithing works, and comparable in fact only to those in small other-smithing works. These integrated-small-shop workers and horsepower are accordingly attributed entirely to these last: in Table 2, cols. 4 – 6, therefore, row 2 is the (rounded) sum of these residuals and the (specialized-small-shop) data for category 4.32, while lines 1 and 3 simply round the (specialized-small-shop) data in Table 1 for categories 4.31 on the one hand and 4.3 net of 4.31 and 4.32 on the other.

The large-shop estimates in rows 1 – 3, cols. 1 – 3 are instead obtained as follows. As can be seen from Table 1, the differences between the demographic-census data and the corresponding industrial-census aggregates in specialized shops equal some 66,650 blue-collar and 100,300 total workers in blacksmithing (4.31), 19,650 and 29,750, respectively, in other smithing (4.32), and just 5,100 and 9,500, respectively, in other fabrication (4.33 – 4.3<u>11</u>, plus, as noted, 4.3ω). The absolute numbers for categories 4.31 and 4.32 are large, those for the residual small, next to the large-integrated-shop figures these need together to reabsorb; moreover, the above pairs of figures yield ratios of blue-collar workers to total workers equal to .66 in categories 4.31 and 4.32, well between the corresponding ratios for specialized large shops and small shops (respectively .89 and .37 in 4.31 and .90 and .44 in 4.32, from Table 1), and .54 for the residual, marginally below the corresponding ratio for specialized small shops (.55, against .92 in specialized large shops, again from Table 1). In short, the non-smithing workers not in the specialized shops counted by the industrial census appear to be not in the large integrated works covered elsewhere by the industrial census, but in small shops; and not in industrial-census integrated small shops, all of which have already been allocated, but in small shops the industrial census missed altogether. On the strength of these considerations, therefore, the present estimates for non-smithing works (Table 2, row 3) simply round the industrial census totals for specialized large shops (cols. 1 – 3) as well as for specialized small shops (cols. 4 – 6), and the entire differences between the census worker totals noted above are attributed to small operations the industrial census missed altogether (cols. 7 – 8). The horsepower corresponding to these last (col. 9) is in turn estimated as their total workers (col. 8) times the horsepower per worker in counted small shops (col. 6/col. 5), discounted by a third. This last correction allows for the knife-grinders missed by the industrial census: Table 1 suggests that these were a very small part of the industrial-census workers in Table 2, row 3, cols. 2 and 5, but near a third of the omitted workers in col. 8, and these were presumably itinerant workers who used no machine power at all. With these estimates in place, the industry-total horsepower figure in col. 12 is then obtained as the simple sum of the partial figures in cols. 3, 6, and 9.

The considerable numbers of workers and horsepower in integrated large shops attributed to category 4.3 thus remain to be distributed between categories 4.31 and 4.32. Since smithing is intrinsically not specialized by output, as already noted, the integration at hand was presumably between metalmaking and subsequent fabrication. Evidence of such integration is provided by the metalmaking data furnished by the Corpo delle miniere, which refer as noted not to throughput at a particular stage of production, but to the actual output of the metalmaking firms; and the available product data point to a far greater incidence of such integration in the case of ferrous metals, where some 50,000 tons of output were fabricated goods ranging from military hardware and railway accessories to nails, than in that of non-ferrous metals, where only 600 tons or so of the listed products were in fact fabricated.[30] That the integrated shops worked ferrous metals is also suggested by the relatively low power-intensity suggested by the present estimates (.54 horsepower per blue-collar worker, against .60 for the large specialized works in category 4.31 and .75 for those in category 4.32); and in light of the above-noted discrepancies between the data in the two censuses it also bears notice that the 34,900 blue-collar and 36,550 total workers (with 18,800 horsepower) here attributed to the engineering component of integrated shops are readily absorbed in 4.31, but not, save perhaps in part, in 4.32. Here, for simplicity, these integrated-shop workers and horsepower are all attributed to category 4.31, raising the large-shop blacksmithing totals to the (rounded) figures transcribed in Table 2, row 1, cols. 1 – 3; by the same token, the estimates for other large smithing works in row 2, cols. 1 – 3, merely round off the corresponding specialized-shop figures in Table 1.

The omitted-worker estimates in Table 2, rows 1 and 2, cols. 7 and 8 are then obtained as residuals, again as col. 10 less cols. 1 and 4, and col. 11 less cols. 2 and 5, respectively. Here too, as in row 8, the omitted shops appear to lie between the included large and small shops; but the absolute numbers involved are altogether larger. In blacksmithing (row 1), the large shops had some .95 blue-collar workers per total worker (col. 1/col. 2), and .52 horsepower per worker (col. 3/col. 2), the small shops .37 blue-collar workers per total worker (col. 4/col. 5),

[30] Corpo delle miniere, *Rivista del servizio minerario 1911*, pp. LVIII-LIX

and .067 horsepower per worker (col. 6/col. 5), the omitted shops an intermediate .50 blue-collar workers per blue-collar worker. Reasoning as above, one can treat this last ratio as a weighted average of the corresponding figures for the large and small shops covered by the industrial census, and apply these weights (.22 and .78) to the corresponding horsepower per worker; the resulting figure equals .167 horsepower per omitted worker, or some 10,650 horsepower in all. But this calculation implies that over 14,000 omitted workers were in large, power-intensive shops; and it is hard to believe that the industrial census could have missed hundreds of large shops (because they were attached to their owners' homes?) in blacksmithing, even as it missed none or nearly none in the no more noisome production of machinery. On the other hand, if all the omitted workers were simply assigned the small shops' .067 horsepower each, the corresponding horsepower would be just 4,250. The present horsepower figure in col. 9 is simply a compromise estimate that allows the omitted shops a weighted average of these two alternative estimates, with a double weight on the lower and less implausible one. The industry-total horsepower figure in col. 12 is again the simple sum of the partial figures in cols. 3, 6, and 9.

In other smithing (row 2), similarly, the large shops had some .90 blue-collar workers per total worker (col. 1/col. 2), and .67 horsepower per worker (col. 3/col. 2), the small shops .42 blue-collar workers per total worker (col. 4/col. 5), and .037 horsepower per worker (col. 6/col. 5), the omitted shops an intermediate .68 blue-collar workers per total worker. Proceeding as before, one can treat this last ratio as a weighted average of the corresponding figures for the large and small shops covered by the industrial census, and apply these weights (.54 and .46) to the corresponding horsepower per worker; the resulting figure equals .379 horsepower per omitted worker, or some 10,700 horsepower in all. Again as before, however, the calculation implies that the industrial census missed hundreds of large shops (with over 15,000 workers). If, instead, all the omitted workers were simply assigned the small shops' .037 horsepower each, the corresponding horsepower would be just 1,050. The present horsepower figure in col. 9 is again simply a compromise estimate that allows the omitted shops a weighted average of these two very different estimates, with a double weight on the lower one.

APPENDIX 2: ESTIMATED CAPITAL COSTS PER HORSEPOWER

The large-shop estimates of capital costs per horsepower in 1911 are derived from the corresponding estimates for 1938, despite some troublesome discrepancies between those two years' censuses. One such is that the horsepower data refer in 1911 to those in use, and in 1938 to those installed; the share of those installed actually in use can well vary across industries and over time, but no evidence can here be brought to bear. Another is that the 1938 census presents the here requisite data only for the "transport equipment" group as a whole. In 1911 that group (categories 4.42 – 4.45) was thoroughly dominated by the rolling-stock and shipbuilding industries (Table 1); in 1938, judging by the detailed sales data (*Censimento i. e c.*, vol. 3, p. 68), the automotive industries had grown to represent some 40% of the group, and aircraft another 20%, with the rolling-stock and shipbuilding industries accounting for just 10% and 25% or so of the total, respectively. Since the limitations of the published data preclude the here desirable disaggregation, the 1938 benchmark for "transport equipment" of 3,702 lire per horsepower (panel B, row 12, col. 6) is here simply considered analogous to a 1911 benchmark for railway vehicles and shipbuilding together of 1,650 lire (the rounded average of the figures in panel A, rows 4 and 5, col. 6); in principle, therefore, the capital-cost estimates for 1911 (panel A, rows 1 – 3 and 6 – 11, col. 6) are the corresponding figure estimated for 1938 (panel B, col. 6), multiplied by the resulting scale factor, or (1,650/3,702).

In practice, the procedure is often complicated by the need to reconcile the categories of the two censuses. In the case of the precious-metal-processing industry, there is a relatively direct correspondence between categories 111 – 112 in the later census (panel B, row 11) and categories 4.59 – 4.510 in the earlier one (panel A, row 10); the per-horsepower estimate in panel A, row 11, col. 6 is simply the corresponding 5,000-lire figure in panel B, row 11, col. 6, suitably scaled. In the case of the precision-equipment industries, the correspondence is less close: categories 105 – 110 in the later census (panel B, row 10) appear dominated by optical and precision instruments (4.51 in 1911); they further include weights and scales (4.52), clocks and watches (4.53), business machines (4.54), and medical equipment (4.58), but omit musical instruments (4.56). The approximation between this set of industries and those in 1911 census categories 4.51 and 4.56 is here deemed close enough, and the per-horsepower estimate in panel A, row 9, col. 6 is simply the 7,169-lire figure in panel B, row 10, col. 6, suitably scaled. For simplicity, this same estimate is attributed to the clocks-and- watches industry as well (panel A, row 10, col. 6).

Categories 80 – 96 and 123 – 126 of the 1938 census appear to correspond, together, to 1911-census category 4.41, which is in turn much the dominant element of 4.4 net of railway vehicles and shipbuilding. The present estimate for the (other) heavy equipment and machinery industry (panel A, row 6, col. 6) is accordingly obtained by calculating the aggregate horsepower, wage bill, and value added of the industries in panel B, rows 1 – 6 and 13 (using cols. 3, 4, and 5), deriving the combined capital cost per horsepower (3,723 lire, comfortingly close to the transport-equipment benchmark), and multiplying it, as before, by (1,650/3,702).

Panel A, row 7 covers the residual (ordinary) machinery industries covered in the 1911 census by categories 4.54, 4.55, 4.57, and 4.58; as is clear from the large-shop data in Table 1 the second of these was then very small, while the other three were about equally large. In the 1938 census, category 133 (row 15) corresponds closely, as noted, to 1911-census category 4.57 (armaments), and categories 97 – 98 (row 7) correspond to at least a large part of 4.58 (other apparatus and instruments); those that correspond to categories 4.54 and 4.55 in 1911 were instead buried in broader aggregates. In 1938, moreover, the armaments industry was much the dominant element of rows 7 and 15 together, and their simple aggregation would attribute to the entire group the relative power-intensity that seems instead peculiar to the armaments industry. In the circumstances, to allow for the changing composition of the relevant group, the present estimate is obtained not by aggregating the underlying data, but by averaging the lire-per horsepower figures in panel B, col. 6, counting that in row 7 twice and that in row 15 once. The resulting weighted average equals 2,733 lire per horsepower; the estimate in panel A, row 7 is this last figure, again multiplied by (1,650/3,702).

Together, categories 99 – 104 of the 1938 census (panel B, rows 8 and 9) appear to correspond relatively closely to 1911-census category 4.3 net of smithing (4.31, 4.32), that is, to panel A, row 3. As in the case of panel A, row 6, col. 6, the present estimate in row 3, col. 6 is obtained by calculating the aggregate horsepower, wage bill, and value added of the relevant industries in panel B (rows 8 and 9, using cols. 3, 4, and 5), deriving the combined capital cost per horsepower (a relatively low 2,416 lire), and multiplying it, as before, by (1,650/3,702). This same figure is here inserted in row 8, col. 6, even though as noted above the 1938 census include weights and scales in the precision-equipment group, because in 1911 the industry was presumably producing, in the main, not the later standard automatic balances, but traditional steelyards and weights: not so much machinery, in essence, as common hardware.

The 1938 census included blacksmithing and other smithing in category 128, among the general trades in panel B, row 14 (127 – 131; 127 referred to vehicle repair, 129 to non-specialized machine shops, 130 to welding and the like, and 131 to the demolition of ships and other metal structures). These activities loomed large in the relevant group's artisanal shops (Table 2), but rather less so among its large "industrial" shops, at least judging from the sales figures in Table 21. On the other hand, for categories 127 – 131 those sales figures sum to far more than the value of production quoted in Table 15, with two possible implications. One is that the value and value added data in Table 15 (and panel B) exclude repair work (127 and much of 129), thus raising the share of smithing in the reported totals; the other is that the labor and horsepower counted in Table 1 (and panel B, cols. 2 and 3) exceed those relevant to the wage bill, and value added, in Table 15 (and panel B, cols. 4 and 5). The internal evidence does not clarify the point: the average wage (the ratio of the wage bill to the blue-collar workers listed in Table 4, discounting females by 50%) for the "general trades" is low but within the norm, suggesting that the data are in fact consistent. With some misgivings, therefore, the estimate in panel B, row 14, col. 6 is here simply scaled in the usual way, and, in the absence of further evidence, attributed to both blacksmiths and other smiths (panel A, rows 1 – 2, col. 6).

The small-shop estimates of capital costs per horsepower in 1911 cannot be similarly derived from corresponding estimates for 1938. The census of 1938 reports data for the other, "artisanal" operations, subaggregated exactly as for the large shops. For these it again reports, by industry – or by region, but not both – aggregate (and subordinate) employment and (installed) horsepower, the wage bill, and the value both of the materials consumed and of the products sold, but not value added (*Censimento i. e c.*, vol. 3, pp. 59, 61). Two aspects of these data bear comment. One is the remarkable variation in the mean wage by region, with the highest over four times the lowest (and a general decline from North to South, but with Latium aligned with the North); average wages also vary across industries, but rather less, with the result that differential skill premiums cannot in fact be estimated (and used to improve the present estimates of labor costs). The other is that the census seems to provide all the elements needed to calculate value added, labor costs, and capital costs in the census year, and thence to derive the corresponding capital-cost estimates for 1911 essentially as was done above for the large shops; but that is not in fact the case. One problem of course is that the reported wage bill refers to only a minority (ca. 30%) of the actual workers, so that the calculation of total labor costs is subject to considerable uncertainty; but the more fundamental difficulty seems to be in the very significance of the reported data, which explains why value added figures were not published at all..

The reported aggregate employment and calculated value added figures (the value of the products sold less that of the materials consumed) are transcribed in Table 3, panel B, cols. 7 – 8; and their anomalies are immediately apparent. In row 14, which refers predominantly to smithing (*Censimento i. e c.*, vol. 3, p. 61, Table 3), for example, calculated value added per worker is under 2,900 lire, well below not only the equivalent large-shop figure of 8,100 lire, but even the large-shop wage bill per (total) worker, near 4,400 lire. The main reason for this peculiar result, and the apparent reason the census did not itself present value added figures for the "artisanal" shops, is that the reported "value of goods sold" seems to be exactly that (see the reproduction of the artisanal-shop census form in *Rilevazioni statistiche*, vol. 8, p. 143): the value of the artisanal shops' repair services was not recorded at all (whereas they apparently were in the case of the industrial shops, *Censimento i. e c.*, vol. 3, pp. 73-106), and if so the aggregate value added that actually corresponds to the reported labor and horsepower could not and cannot be calculated at all. It bears notice that the (here irrelevant) foundries did not engage in repair work, and within that group the calculated value added per worker of the artisanal works is practically identical to that obtained for the industrial works (itself, oddly, fractionally greater than the reported figure, p. 67). One also notes that in row 15 (armaments) the calculated value added per worker is an impossibly high 36,500 lire, against 10,400 in the corresponding large shops; and a mere typographical error is to be excluded, as the disaggregated figures in census Table 3 sum to the reported totals.

APPENDIX 3: ESTIMATED UNIT METAL CONSUMPTION AND VALUE ADDED

The estimates of 1911-price value added, and metal consumption, per ton of new production in the various industries separately identified here are transcribed in Table 4, rows 1, 7 – 9, 13, and 16 – 17, cols. 5 and 7, respectively; but since even those industries are typically aggregates of heterogeneous activities, the estimates provided here can be no more than representative. The estimates of value added per ton of course incorporate the input-output ratios; the latter are here considered first.

New production by the fabricated metal industry is considered as a single aggregate, spanning the gamut from anchors and anvils to pins and needles (Table 4, row 1). Input-output ratios in (traditional) fabrication are abundantly documented in the literature. Giordano suggests ratios varying from 1.1 for rural implements (including anvils) and heavy forgings (anchor chains) to 1.2 for horseshoes and wagon fittings, 1.3 for small marine fittings and armor plate, and 2.0 for military tools, harnesses, swords, and extensively forged pieces.[31] The estimated average adopted here is 1.35 tons of metal per ton of output (Table 4, row 1, col. 7).

New production by the general equipment industry is here divided into three very unequal parts. One is the assembly of machines from imported parts (Table 4, row 7), separated out because value added per ton of output is obviously far less than in the production of the same machines from semi-finished metal, and net imports of parts are documented by the trade statistics; as noted above, the cyclical variability of those imports suggests the present interpretation of their use.[32] The relevant input-output ratio here is of course zero (Table 4, row 7, col. 7, whence of course zero total metal consumption, col. 3, and metal consumption per worker, col. 8). Another is the production of truss-structure components (for bridges, canopies, and power-line towers, Table 4, row 8); it is separated out because value added per ton is again relatively low, and to take direct advantage of the available data points (and thus to ensure that the time-series estimates remain consistent with them). The input-output ratio is here set at 1.2 (row 8, col. 7), as suggested by the ratio of total duty-free metal imports for bridges and canopies to the corresponding total exports from their inception in 1891 through 1907; later flows are ignored, as much imported metal appears never to have been reexported in fabricated form. The third component covers the rest of the industry (Table 4, row 9), producing everything from storage tanks to hand-guns and sewing machines. Giordano's ratios for ordinary (heavy) equipment appear near 1.2 to 1.4, but up to 2.5 for individual parts, while Falco uses a figure of 1.23 in the production of general machinery, most of it for metal to be cast; a ratio of 1.25 is tentatively adopted here (Table 4 , row 9, col. 7).[33]

The two identified components of the precision-equipment industry are treated asymmetrically. The new production of precision instruments is treated as a single aggregate (Table 4, row 13); trade in parts was recorded only for musical instruments, and even assuming they were all metallic the quantities involved appear to have been insignificant.. Giordano's

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[31] F. Giordano, *L'industria del ferro in Italia: relazione dell'ingegnere Felice Giordano per la Commissione delle ferriere istituita dal Ministero di marina*, Turin, 1864, pp. 40-41, 90, 340, 415; hardware for buildings is allowed a ratio of 1.2 on p. 40, and 1.7 on p. 41. The relative age of this source does not appear to be a major handicap, as the subsequent technical progress appears to have been mostly labor- and perhaps fuel-saving rather than materials-saving.

[32] The description of the derivation of the net import series cannot be included here; it is available on request.

[33] Giordano, *L'industria del ferro*, pp. 419-421; R. Falco (Comitato nazionale per le tariffe doganali e la revisione dei trattati di commercio. Associazione nazionale tra gli industriali meccanici e affini), *L'industria meccanica in Italia. Ragioni e condizioni del suo sviluppo*, Milan, 1916, p. 36.

figures recalled above suggest that the input-output ratio rose as pieces became smaller and more extensively worked; it is here tentatively set at 2.5 (Table 4, row 13, col. 7). In the case of clocks and watches, on the other hand, part imports were relatively significant, and again cyclically variable; that in Italy pocket watches were typically assembled from imported parts is explicitly noted by the *Riassunto industriale* (vol. 1, pp. 58-59). Here too, therefore, new production is disaggregated to distinguish the assembly of imported parts (Table 4, row 16) from production from metal (row 17). The input-output ratio is of course zero in mere assembly (Table 4, row 16, col. 7, whence again zero total metal consumption, col. 3, and metal consumption per worker, col. 8); in new production from metal (which includes a tail even of tower clocks), the input-output ratio is again tentatively set at 2.5 (Table 4, row 17, col. 7). It may be noted that both branches of the precision equipment industry were relatively small, in value added terms, and characterized by a relatively low consumption of metal per unit of value added: their aggregate consumption of metal was correspondingly a very minor part of the engineering-industry total, and here at least the errors in the input-output ratios are of little consequence.

The estimates of value added per ton are derived in the main from the above input-output ratios, and the prices (plus tariffs) indicated by the *Movimento commerciale 1911*.[34] Typical (ferrous) metal costs appear to have ranged from 220 lire per ton for large bar (import category 675) to 360 for thin plate (682a), and fuel costs may have added some 10% to that.[35] Fabricated metal values per ton range from 800 lire for common utensils (721) to over 1,000 lire for most unspecified small metal (716b), better utensils (sickles and the like: 723), and heavy files (725), over 3,000 lire for fine files (727), and 10,000 lire for pins and needles (729); on the other hand, the (Turin) Cooperativa works in the Grioni sample (Appendix Table 1, panel A, line 24) reported a production of 500 tons of files, and sales of 300,000 lire, for an average value of just 600 lire per ton. Materials costs per ton of output can be estimated at approximately 360 lire for 1.35 tons of metal (a mix of medium bars at 250 lire per ton, thick plate at 230 lire per ton, and medium plate at 310 lire per ton, categories 676, 680a and 681a), and 35 lire for fuel and other costs, or 395 lire in all. Value and value added are less readily pinned down, not least because the cited figures from the Grioni sample sit poorly with the others; but as will be seen below the fabricated-metal industry was much the largest consumer of metal, and at the end of the day a reasonable estimate of that consumption requires that the corresponding value added per unit of output be kept within relatively narrow bounds. The figure selected here is 415 lire per ton (Table 4, row 1, col. 5); the implied average unit value is 810 lire per ton, which seems reasonable enough next to the baseline 800 lire for common utensils derived from the *Movimento commerciale*.

The trade data for temporary imports and reexports from 1909 to 1913 (*Movimento commerciale 1913*, vol. 1, Tables XVI and XVII) suggest that (the components of) bridges and canopies belonged mostly to category 712, with a ca. one-third share spread over categories 711, 713, and 716, while the metal input belonged mostly to category 675, with a ca. one-third share in category 680. Including tariffs, which were presumably reflected even in the domestic-market output price, average prices per ton would appear to have been near 650 lire for the output, and 225 for the metal input. Allowing 1.2 tons of the latter per ton of the former and 30 lire for fuel and other costs, value added in the production of the components of bridges and canopies (and, by extension, of power-line towers) is here set at 350 lire per ton of output (Table 4, row 8, col. 5).

[34] Direzione generale delle dogane e delle imposte indirette, *Movimento commerciale del regno d'Italia* (annual), briefly *Movimento commerciale*. These prices were set annually, retrospectively, by a committee of experts.

[35] Falco, *L'industria meccanica*, p. 36.

Ordinary heavy equipment was valued at prices (including tariffs) ranging from 1,000 lire per ton for boilers with cast-iron pipes (794) to over 2,500 lire per ton (marine engines: 805), but typical prices seem to range from 1,200 to 1,400 lire per ton (medium machine tools, hydraulic motors, steam engines, agricultural machinery, general machinery: 798, 800-802, 804, 806-807, 821). Lighter equipment was of course worth much more: per ton, import prices plus tariffs ranged from ca. 2,700 lire for sewing machines and 2,800 lire for heating, refining, and distilling apparatus (category 828) and gas meters (833) to 4,500 lire for electric appliances (834) and 8,000 to 10,000 lire for firearms (788b, ordinary rifles, at 40 lire and an estimated 4 kilograms each; 791, pistols, at 12.5 lire each and an estimated 1.5 kilograms each); conversely, storage tanks and the like were plausibly worth no more, or even less, than the 650 lire per ton attributed to the components of bridges and canopies. Taking roughly modal values (for ordinary machinery), one can allow 1,300 lire per ton of output, 315 lire for 1.225 tons of ferrous metal (a mix of bars, thick and medium plate, and cast iron, with this last valued at 250 lire per ton), 50 lire for .025 tons of non-ferrous metal (copper bar, at near 2,000 lire per ton, category 731), and 35 lire for fuel and other costs, for a value added per ton of output from semi-finished metal at a round 900 lire per ton. This modal value plausibly doubles as the relevant mean. On the one hand, one notes that if one allows a value added per ton of 300 lire for low-fabrication goods ("storage tanks"), and 3,000 lire, on average, for high-fabrication goods (light equipment), the two tails together average 900 lire per ton if the total value added of the high-fabrication tail is just short of three times that of the low-fabrication tail (if per million lire of value added by the latter, corresponding to 3,333 tons of goods, the former generates 2.857 million lire of value added, with 953 tons of goods, together they account for 3.857 million lire of value added and 4,286 tons of goods, or 900 lire per ton). On the other, a ca. 3 to 1 ratio between these two tails seems entirely consistent with the census data and resulting value added estimates (Tables 1 – 3): considering only the large shops (which accounted for the larger part of total employment, and the bulk of that in new production), the low-fabrication tail may not unreasonably account for some 2,300 workers (in category 4.58) of the 25,300 workers in Table 2, row 7, col. 2, leaving some 23,000 to the high-fabrication tail, and some 5,500 workers in category 4.41 (leaving to the middle of the distribution the rest of the 53,500 in Table 2, row 6, col. 2, net of the independently estimated 5,500 making truss-structure components, Table 4, row 4, col. 4); allowing for relative value added per worker, equal in round figures to some 2,200 lire in row 6 and 2,100 lire in row 7 (from the estimates in Table 3, panel A, rows 6 and 7, col. 7), the low-fabrication tail would account for some 17 million lire of value added, and the high-fabrication tail for 48 million lire, or just under three times as much. The above estimate of 900 lire per ton, derived for ordinary machinery, is accordingly applied unchanged to (all) residual new production of ordinary equipment from metal (Table 4, row 9, col. 5).

Machine parts were valued at prices per ton, including tariffs, ranging from 810 lire for ordinary parts of ferrous metal (827a) and 2,760 for ordinary parts of non-ferrous metal (827d) through 3,850 for sewing-machine parts (826) and 5,500 for finished bicycle parts (875) to 23-25,000 for finished rifle and pistol parts (790, 793). Ordinary non-ferrous parts accounted for over 40% of (gross) imports, raising their average value to over 2,200 lire per ton, or well above that of typical machines; in the small, too, complete sewing machines were valued at 2,950 lire per ton (815), or less than their imported parts. In general, therefore, imported parts appear to have been either the components of peculiarly expensive machines, or the peculiarly expensive components of ordinary machines; either way, the import mix was clearly not representative of that in production. Here, value added in assembly is estimated directly at 300 lire per ton, or a third of the above estimate for machine production from metal, leaving twice that for the production of the component parts. This split in value added between the manufacture of parts and the process of assembly would seem reasonable for that time, when the former stage of production had been largely mechanized and the latter was still carried out very much by hand, without the gains that would come from assembly lines. Again, the implied average value of ordinary parts equals a round 1,000 lire per ton. The latter can be taken to include some 55 lire for non-ferrous parts, allowed a 2% share of the machine's weight, and therefore ca. 965 lire per ton of ferrous parts, again not unreasonable given average import values (near 900 lire per ton for sewing-machine parts and ordinary ferrous parts together, rising to an impossible ca. 1,700 including bicycle parts). Finally, the implied 60% ratio of value added to value in the production of machine parts sits comfortably next to the ca. 50% allowed fabricated metal, and the higher figures allowed, in what follows, to precision equipment.

In precision equipment the ratio of value added to value was relatively high (*Censimento i. e c.*, vol. 3, p. 67, Table 15). Standard non-optical precision instruments (of steel or copper alloys) were valued at import prices (plus tariffs) of 20,300 lire per ton (831a), musical instruments at even higher rates (1170-1173). Value added per ton is here tentatively set at 75% of 22,000 lire per ton of output, or 16,500 lire (Table 4 , row 13, col. 5); this estimate is consistent for example with the consumption of 2.5 tons of copper alloy in bars (731), costing some 5,000 lire, and 10% of that for fuel and other materials.

Value added in the production of clocks and watches from metal is particularly difficult to pin down. Including tariffs, imported parts were valued at 32,500 lire per ton (category 859a); assembled mechanisms for pocket watches at 4.75 lire each (category 856), for table and grandfather clocks at 9 lire each (category 857), and for tower clocks at 4,000 lire per ton; complete watches of ordinary metal, at just 4.0 lire each (category 851b), or less than the corresponding assembled mechanisms, and complete (non-electric) clocks not in cases at 20 lire each (category 853). Again allowing pocket watches 100 grams each, and clocks without cases 1,000 grams each, these last values correspond to some 40,000 lire per ton of watches, and 20,000 lire per ton of ordinary clocks, and proportionately less, obviously, with higher weights per piece (and as noted 4,000 lire per ton of tower clocks, where the assembled mechanism was in fact the finished product). On the other hand, Grioni reports data for the very significant Borletti works (and suggests that the only other significant producers, the Junghans works, were less than half its size; and the easiest way to generate estimates consistent with those firm data is simply to incorporate them.[36] Borletti employed 700 blue-collar workers in 1912, with an output of 643,030 (cheap) watches and 176,000 alarm clocks, for an estimated output weight of 117.1 tons; production in 1911 equaled 523,400 watches and 175,000 clocks, for an estimated output weight (again at 100 and 300 grams per piece, respectively) of 104.84 tons, near 90% of that of 1912. In 1911, neglecting productivity growth, Borletti would have employed some 630 blue-collar workers, or 70% of the estimated large-shop total in 1911 (Table 2, row 10, col. 1); allowing the Borletti works 70% of the estimated large-shop value added (2.22 million lire, Table 3, panel A, row 10, col. 7), or 1.554 million lire, one obtains a value added estimate of 14,800 lire per ton. Allowing for modest productivity growth, the present estimate of value added is set at a round 15,000 lire per ton (Table 4, row 17, col. 5); since it is obtained in essence for simple watches and small clocks, more complex watches and larger clocks are implicitly assumed to offset each other. This estimate is low, next to the above-noted import values (and assumed weights per piece); but since it is clear from those values that the imported assembled watch-mechanisms were more complex than those in imported watches, it is also quite possible that the imported watches were finer, on average, than those produced in bulk within Italy. Again, the present estimate is obviously sensitive to the assumed average weight of individual time-pieces; but since it finally serves only to back out metal consumption, which is in any case trivially small, its uncertainty can be taken in stride.

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[36] See Appendix Table 1, panel E, lines 3 and 6; also Grioni, *Annuario*, vol.2, p. 329.

A similar uncertainty surrounds the estimate of value added in assembling imported watch parts (to obtain watches apparently finer than those typically produced in Italy from metal). Using the above import values for parts and assembled mechanisms, value added per ton equals (47,500 – 32,500), or 15,000 lire with the assumed 100-gram weight per piece, declining with increasing weight to vanish altogether just short of 150 grams per piece. Here, value added per ton is set very simply at a round 8,000 lire per ton (Table 4, row 16, col. 5), which allows assembly a not unreasonable 20% or so of the value of the assembled piece (and implies for example that a ratio of value added to value of 70% in the manufacture of those parts yields one near 75% for the assembled mechanisms). This particular estimate is without practical implications for metal consumption; as will be seen below it serves essentially to allocate the industry's small-shop employment between assembly work on the one hand and maintenance work on the other.

APPENDIX 4: THE GRIONI SAMPLE

Grioni's publication is a two-volume directory of the firms in the metal-processing industries, including mining, metalmaking, and engineering.[37] Volume 1, in two parts, is the directory proper. Part I is organized geographically, region by region, within region by province, within provinces by localities, in alphabetical order following the provincial capital. The firms in each locality are listed alphabetically by name, and for each there is at least a brief indication of its sector of activity (for example, the first page lists the forty-odd firms in the province of Aquila, in the Abruzzi; most of them are identified simply as machine shops, a few as foundries, one as a bauxite mine). The total number of firms listed in the 300-odd pages of Part I appears to be near 8,000, including everything from mines and steel mills to bicycle repair shops; by way of comparison, the *Censimento industriale* counted over 41,000 firms in categories 2.11-2.12 (metal mining, with under 200 firms) and 4 (metalmaking and metalworking, with 41,100 firms), and some 18,000 even excluding smithing firms (categories 4.31-4.32, with 23,200 firms; vol. 4, pp. 508, 512, 522). Part II, approximately half as long as Part I, is a re-listing of those same firms, by sector of activity. The sectors are numerous and relatively detailed; a final index provides cross-references, and lists, for example, 16 different headings related to automobiles. Firms are identified only by name and location, and may appear under multiple headings. The individual entries here number some 100 per page, for a total in the neighborhood of 15,000, with, obviously, very many duplications (which reflect the nature of the classification as well as a widespread lack of specialization: the F.I.A.T. works thus appear four times on pp. 425-426 alone, as producers of both generic and Diesel-type heavy oil engines, again as producers of internal-combustion/gasoline engines, and yet again as producers of airplane engines). Volume 2, of over 500 pages, contains part III, a set of some 80 company hagiographies apparently supplied by the firms themselves. These contain occasional data, numerous photographs, and much trumpeting of success, especially on world markets.

For a small minority of firms, Part I of the directory also provides a capsule description that may specify the number of workers and horsepower, the types of products, perhaps their quantity or value. The more useful of these micro-data are summarized in Appendix Table 1. Col. 1 notes the source page; col. 2 identifies the firm by a short name (or acronym), and col. 3 its activity or product. Col. 4 transcribes the reported number of blue-collar workers (with a few exceptions, estimated as noted below). Col. 5 transcribes the weight of output, as reported (where col. 6 is blank), or as estimated from the reported sales transcribed in col. 6; the ratio of

[37] Grioni, *Annuario*.

col. 6 to col. 5 is of course the estimated value per ton of output (normally a round 1,000 lire per ton of hardware and 1,300 lire per ton of heavy machinery, with higher figures for light equipment; these refer in principle to 1912, allowing for reporting and publication lags, but correspond in fact to those estimated below for 1911, noting the comparatively small price changes suggested by the *Movimento commerciale 1911* and *1912*). Col. 7, the estimate of physical product per (blue-collar) worker, is of course the ratio of col. 5 to col. 4; and col. 8 is the ratio of the reported horsepower (not transcribed here) to the reported workers in col. 4. The better to highlight the here relevant information, the individual observations are grouped as in the 1911 census (Table 1), with "fabricated metal" corresponding to category 4.3, "heavy engineering" to categories 4.41, 4.43, and 4.45, and "light engineering" to categories 4.51 – 4.510. The heavy engineering sector is itself subdivided to separate road vehicles, machinery, and (components of) structures; and within each group the observations are arranged in ascending order of product weight per worker (col. 7).

Foundries are excluded from the sample, unless the firm produced machinery, and so of course are firms producing ships or rail-guided vehicles. A few more are excluded because reported production appears far too low to cover even the likely wage bill of the reported workers (the Russo, Lancini, Galdabini, Tessarotto, Mangelli, and Cerasi works listed on pp. 43, 113, 130, 135, 225, and 281, respectively). The internal evidence suggests an order-of-magnitude misprint, typically in the sales figures; symmetric errors are of course also possible, but there are none so obvious as clearly to exclude genuine cases of high productivity. Finally, some firms straddled the present groups, and are here assigned to one of these with considerable uncertainty.[38]

Some detailed notes may assist in the reconstruction of Appendix Table 1. Some figures are simply the mid-point of the reported range. Bicycles, motorcycles, and motor-cars are allowed .02, .05, and 1.00 tons per unit, respectively (assuming motorcycles were then little more than heavy, powered bicycles, as suggested by the photograph in Part III, p. 518); alarm clocks and watches, .30 and .10 kilograms per unit, respectively; rifles, 4 kilograms per unit. The output estimated for the Rusconi works (p. 146) includes 1,900 tons reported as such, with the residual calculated from its sales value. The actual number of workers at the Frera works (p. 161) is taken from Part III (p. 514). The Savigliano works (p. 195) appear thrice. It had four shops; two are attributed the reported output and, at a guess, one fourth the total labor force, while the entire firm is attributed an output that includes allowances of 10,000 tons for railway vehicles and, again at a guess, 2,500 tons of electrical equipment.

The sample entering Appendix Table 1 is relatively small, as it finally includes just 146 firms. Not surprisingly, these are, on average, relatively large, with a mean of some 160 blue-collar workers per firm; by way of comparison, the firms with more than 10 subordinate workers counted by the *Censimento industriale*, vol. 3 in the relevant categories (4.3; 4.4, excluding 4.42 and 4.44; 4.5, excluding 4.59 and 4.510; 4.ω) totaled 2,260, with 137,168 blue-collar workers, for an average nearer 60. The sample firms (that reported horsepower) were also relatively power-intensive, with, overall, some .6 horsepower per worker; the census large firms in the relevant categories averaged as much or more (over .5 in use, and obviously more installed), but that was well above the estimated overall average of about .4 including small firms (Table 2). Finally, and not surprisingly, given that Grioni himself appears to have been based in

38 The regional estimates of engineering-industry value added per worker in 1911 V. Zamagni, *Industrializzazione e squilibri regionali in Italia. Bilancio dell'età giolittiana*, Bologna, 1978, p. 69, are also apparently based on Grioni's data. Her figure for Campania is relatively low (astonishingly so, unless one is already convinced that Southerners were relatively unproductive); one wonders whether it is biased downward by the inclusion, in the small local sample, of the Russo works in Caserta, here excluded because their output appears to have been understated, through a simple typographical error, by a factor of 10.

Milan, the sample is geographically biased even with respect to Grioni's own listing: the latter devoted a quarter of its pages to Lombardy and another ninth to Piedmont, but of the firms that responded to his request for information with enough data to be included in the present sample almost half were Lombard, another sixth Piedmontese.

Appendix Table 1, col. 7 suggests that product weight per (blue-collar) worker varied widely, both within and across the present groups; the differences in product per worker seem due primarily not to differences in size or power-intensity, but to differences in the products themselves. Within the fabricated-metal group, those near one ton per worker were producing brass- and copperware, swords, and hand-forged nails; at the other extreme, the 33 tons per man of the Tocco works may have been achieved in the main by simply stamping out corrugated sheet. Within heavy engineering, product per worker in the production of structures ranges from some three tons of relatively complex goods (gates, spiral staircases, and the like) to ten times that of relatively simple large elements (pressure pipelines and the like; the even higher figure obtained for part of the Savigliano works is only indicative, as the actual labor force is unknown). Product per worker in the production of general machinery ranged from in the main from two to ten tons; the even higher figures at the top of the scale appear to consist largely of castings, while the total product of the Savigliano works includes 18,000 tons of structures. Product per worker in the production of road vehicles was instead much lower, ranging from one third of a ton to ten times that for complete vehicles, with higher figures for those who merely produced parts. The lowest products per worker were naturally registered in light engineering, with well under a tenth of a ton for watches and precision instruments, a tenth to a quarter of a ton for firearms, one or two tons for electrical equipment (the Greco works appear also to have cast columns), and some two to four tons for sanitary equipment, cheap stoves, and the like. The inverse of col. 7 illustrates the variation in the labor input, and derivatively in the likely wage bill and value added, per ton of metal: over the full set of sample observations the number of blue-collar workers per ton of product varies up from .025 through approximately .150, .300, and .500 at the quartiles to a peak of 50.000.

Table 1
Reported Labor Force and Factor Employment in Engineering in 1911

Census category		*Censimento demografico* (labor force)		*Censimento industriale* (total)			
				Employment		Unduplicated horsepower in use	
Code	Content	Blue-collar	Total[c]	Blue-collar	Total	Primary	Electric
4.31	Blacksmiths, wrought iron work	86,879	150,582	20,230	50,302	3,653	1,218
4.32	Coppersmiths, tinsmiths, braziers	29,736	49,168	10,104	19,435	853	2,099
4.33	Metal furniture	5,717	7,318	5,064	6,085	44	357
4.34	General hardware	7,431	8,856	5,930	6,807	1,326	1,401
4.35	Cables, springs, tin cans	5,500	7,259	3,717	4,548	1,168	809
4.36	Ordinary-metal medals and coins	127	176	17	27		18
4.37	Ordinary table- and kitchen-ware	2,239	2,761	1,958	2,262	699	212
4.38	Knives, scissors, swords	1,871	3,027	1,272	1,996	535	245
4.39	Knife-grinders	1,710	3,922	275	812	34	202
4.310	Ordinary bullets, shot, fuses, cases	503	*551*	260	300	86	58
4.311	Enamelware, other metal objects	3,045	4,316	2,272	3,125	243	917
4.3ω	(4.31 - 4.311)			2,269	2,745	329	436
4.3	Fabricated metal products	144,758	237,936	53,368	98,444	8,970	7,972
4.41	Structural components, machinery	49,245	*61,692*	46,020	58,087	11,237	14,362
4.42	Rail-guided vehicles	44,120	*48,147*	42,049	45,747	17,889	15,284
4.43	Bicycles, automobiles	12,809	*16,781*	11,843	15,556	674	3,432
4.44	Shipyards and boatyards	28,932	*31,347*	26,151	28,227	8,407	8,566
4.45	Aircraft	1,286	*1,434*	403	460	61	118
4.4ω	(4.41 - 4.45)			7,348	7,925	1,325	2,831
4.4	Heavy equipment, machinery	136,392	*159,401*	133,814	156,002	39,593	44,593
4.51	Optical and precision instruments	1,226	1,722	734	1,002	92	260
4.52	Common weights and scales	1,980	2,995	1,537	2,275	39	162
4.53	Clocks and watches	3,861	8,801	1,468	2,417	161	218
4.54	Business machines	145	*226*	97	131	1	13
4.55	Electrical apparatus	7,717	*8,715*	7,157	7,884	259	2,753
4.56	Metal musical instruments	922	1,234	622	771	20	69
4.57	Firearms, grenades, torpedoes	9,551	*11,316*	8,093	9,244	4,196	3,564
4.58	Other apparatus and equipment	10,571	*13,453*	10,294	12,798	1,450	4,390
4.59	Goldsmiths and silversmiths	13,487	21,064	7,993	11,051	64	711
4.510	Precious-metal medals and coins	285	446	227	277	25	45
4.5ω	(4.51 - 4.510)			434	659		67
4.5	Light equipment, precious-metal products	49,745	69,972	38,656	48,509	6,307	12,252

Table 1, cont.

Census category		*Censimento demografico* (labor force)		*Censimento industriale* (total)			
				Employment		Unduplicated horsepower in use	
Code	Content	Blue-collar	Total[c]	Blue-collar	Total	Primary	Electric
4.ω1	(4.1 - 4.5)[d]			27,411	29,286	18,884	9,513
4.ω2	(4.3 - 4.5)			11,733	14,321	3,058	2,489
4.ω				39,144	43,607	21,942	12,002
ω.31	(3.1[e], 3.2[f], and 4[f])			9,588	10,980	1,657	1,893
ω.71	(4[d] and 5[g])			3,607	4,371	3,062	520

Table 1, cont.

Census category		*Censimento industriale* (large shops)[a]				*Censimento industriale* (small shops)[b]			
		Employment		Unduplicated horsepower in use		Employment		Unduplicated horsepower in use	
Code	Content	Blue-collar	Total	Primary	Electric	Blue-collar	Total	Primary	Electric
4.31	Blacksmiths, wrought iron work	2,870	3,222	1,514	198	17,360	47,080	2,139	1,020
4.32	Coppersmiths, tinsmiths, braziers	3,157	3,491	502	1,856	6,947	15,944	351	243
4.33	Metal furniture	3,797	4,197	34	271	1,267	1,888	10	86
4.34	General hardware	5,160	5,577	1,219	1,280	770	1,230	107	121
4.35	Cables, springs, tin cans	3,041	3,308	1,062	547	676	1,240	106	262
4.36	Ordinary-metal medals and coins	0	0	0	0	17	27	0	18
4.37	Ordinary table- and kitchen-ware	1,846	1,958	544	202	112	304	155	10
4.38	Knives, scissors, swords	837	927	238	152	435	1,069	297	93
4.39	Knife-grinders	40	45	9	0	235	767	25	202
4.310	Ordinary bullets, shot, fuses, cases	242	264	79	55	18	36	7	3
4.311	Enamelware, other metal objects	1,182	1,380	231	377	1,090	1,745	12	540
4.3ω	(4.31 - 4.311)	1,950	2,102	225	391	319	643	104	45
4.3	Fabricated metal products	24,122	26,471	5,657	5,329	29,246	71,973	3,313	2,643
4.41	Structural components, machinery	34,878	38,819	9,601	11,710	11,142	19,268	1,636	2,652
4.42	Rail-guided vehicles	41,673	45,276	17,346	14,028	376	471	543	1,256
4.43	Bicycles, automobiles	8,039	8,862	573	2,839	3,804	6,694	101	593
4.44	Shipyards and boatyards	26,116	28,186	8,407	8,551	35	41	0	15
4.45	Aircraft	383	436	6	114	20	24	55	4
4.4ω	(4.41 - 4.45)	7,103	7,509	1,309	2,798	245	416	16	33
4.4	Heavy equipment, machinery	118,192	129,088	37,242	40,040	15,622	26,914	2,351	4,553
4.51	Optical and precision instruments	479	621	91	206	255	381	1	54
4.52	Common weights and scales	684	779	34	104	853	1,496	5	58
4.53	Clocks and watches	907	1,015	150	205	561	1,402	11	13
4.54	Business machines	45	52	1	12	52	79	0	1
4.55	Electrical apparatus	6,777	7,336	38	2,625	380	548	221	128
4.56	Metal musical instruments	482	529	12	51	140	242	8	18
4.57	Firearms, grenades, torpedoes	7,661	8,229	4,173	3,521	432	1,015	23	43
4.58	Other apparatus and equipment	8,152	9,466	1,291	4,149	2,142	3,332	159	241
4.59	Goldsmiths and silversmiths	4,669	5,274	57	525	3,324	5,777	7	186
4.510	Precious-metal medals and coins	227	275	25	45	0	2	0	0
4.5ω	(4.51 - 4.510)	202	220	0	53	232	439	0	14
4.5	Light equipment, precious-metal products	30,285	33,796	5,872	11,496	8,371	14,713	435	756

Table 1, cont.

Code	Content	*Censimento industriale* (large shops)[a] Employment Blue-collar	Total	Unduplicated horsepower in use Primary	Electric	*Censimento industriale* (small shops)[b] Employment Blue-collar	Total	Unduplicated horsepower in use Primary	Electric
4.ω1	(4.1 - 4.5)[d]	27,138	28,901	18,797	9,415	273	385	87	98
4.ω2	(4.3 - 4.5)	10,116	10,941	2,932	2,295	1,617	3,380	126	194
4.ω		37,254	39,842	21,729	11,710	1,890	3,765	213	292
ω.31	(3.1[e], 3.2[f], and 4[d])	8,977	9,610	1,418	1,831	611	1,370	239	62
ω.71	(4[d] and 5[g])	3,305	3,916	3,047	437	302	455	15	83

[a]shops with more than ten subordinate workers.
[b]shops with up to ten subordinate workers.
[c]the italicized figures include no artisans.
[d]metalmaking, engineering.
[e]wood products excluding cane, reed, and straw ware.
[f]cane, reed, and straw ware.
[g]non-metallic mineral products, construction.

Sources: *Censimento demografico*, *Censimento industriale*.

Table 2
Estimated Factor Employment in Engineering in 1911

	Census code	Census category	(1) *Censimento industriale* large shops[a]: Employment: Blue-collar	(2) *Censimento industriale* large shops[a]: Employment: Total	(3) *Censimento industriale* large shops[a]: Unduplicated horsepower in use	(4) *Censimento industriale* small shops[b]: Employment: Blue-collar	(5) *Censimento industriale* small shops[b]: Employment: Total	(6) *Censimento industriale* small shops[b]: Unduplicated horsepower in use
1.	4.31	Blacksmithing	37,750	39,750	20,500	17,350	47,100	3,150
2.	4.32	Other smithing	3,150	3,500	2,350	7,250	17,400	650
3.	other 4.3	Other fabricated metal	18,100	19,750	6,900	4,950	8,950	2,200
4.	4.42	Rail-guided vehicles	43,700	47,700	32,900	400	450	1,800
5.	4.44	Shipyards and boatyards	28,900	31,300	18,750	50	50	0
6.	other 4.4	Other heavy equipment, machinery	48,150	53,500	27,650	15,200	26,400	5,100
7.	4.54/5/7/8	Other ordinary machinery	22,850	25,300	15,850	5,150	8,400	1,300
8.	4.52	Weights and scales	700	800	150	850	1,500	50
9.	4.51/6	Precision instruments	950	1,150	350	400	600	100
10.	4.53	Clocks and watches	900	1,000	350	550	1,400	0
11.	4.59/10	Precious-metal products	4,900	5,550	650	3,300	5,800	200

	Census code	Census category	(7) Other shops: Employment: Blue-collar	(8) Other shops: Employment: Total	(9) Other shops: Unduplicated horsepower in use	(10) Industry totals: Employment: Blue-collar	(11) Industry totals: Employment: Total	(12) Industry totals: Unduplicated horsepower in use
1.	4.31	Blacksmithing	31,800	63,750	6,400	86,900	150,600	30,050
2.	4.32	Other smithing	19,350	28,250	4,250	29,750	49,150	7,250
3.	other 4.3	Other fabricated metal	5,100	9,500	1,550	28,150	38,200	10,650
4.	4.42	Rail-guided vehicles	0	0	0	44,100	48,150	34,700
5.	4.44	Shipyards and boatyards	0	0	0	28,950	31,350	18,750
6.	other 4.4	Other heavy equipment, machinery	0	0	0	63,350	79,900	32,750
7.	4.54/5/7/8	Other ordinary machinery	0	0	0	28,000	33,700	17,150
8.	4.52	Weights and scales	450	700	50	2,000	3,000	250
9.	4.51/6	Precision instruments	800	1,200	150	2,150	2,950	600
10.	4.53	Clocks and watches	2,400	6,400	100	3,850	8,800	450
11.	4.59/10	Precious-metal products	5,550	10,150	300	13,750	21,500	1,150

[a]shops with more than ten subordinate workers.
[b]shops with up to ten subordinate workers.

Sources: see text.

Table 3
Estimated Value Added in Engineering in 1911

A. Estimates for 1911

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		Women, boys and girls			Value added (million lire)							
					Large shops				Small shops			
						Capital costs						
	Industry	Total	Large shops	Other shops	Labor costs	Total	Lire/HP	Total	Labor costs	Capital costs	Total	Total
1.	Blacksmithing	19,500	4,750	14,750	48.03	21.65	763	69.68	124.17	22.81	146.98	216.66
2.	Other smithing	5,950	650	5,300	4.09	2.30	763	6.39	51.60	10.19	61.79	68.18
3.	Other fabricated metal	9,150	7,300	1,850	20.90	10.04	1,077	30.94	21.03	6.67	27.70	58.64
4.	Rail-guided vehicles	2,300	2,300	0	60.25	64.91	1,654	125.16	0.00	0.00	0.00	125.16
5.	Shipyards and boatyards	1,350	1,350	0	39.32	35.76	1,645	75.08	0.00	0.00	0.00	75.08
6.	Other heavy equipment, mach.	7,100	5,250	1,850	65.33	54.04	1,659	119.37	30.57	12.28	42.85	162.22
7.	Other ordinary machinery	5,700	4,900	800	29.44	22.99	1,218	52.43	9.60	2.78	12.38	64.81
8.	Weights and scales	300	150	150	.93	.28	1,077	1.21	2.55	.43	2.98	4.19
9.	Precision instruments	500	200	300	1.35	1.29	3,195	2.64	2.21	1.08	3.29	5.93
10.	Clocks and watches	700	500	200	.98	1.24	3,195	2.22	10.38	1.62	12.00	14.22
11.	Precious-metal products	3,900	2,100	1,800	5.84	2.18	2,229	8.02	20.18	3.64	23.82	31.84

Table 3, cont.

B. Data for 1938

	1938 census code	Industry	(1) 1911 census code	(2) Large industrial shops[a]: Employ-ment	(3) Large industrial shops[a]: Installed horse-power	(4) Large industrial shops[a]: Wage bill[b]	(5) Large industrial shops[a]: Value added[b]	(6) Large industrial shops[a]: Net capital costs per horsepower[c]	(7) Other shops: Employ-ment	(8) Other shops: Value added[d]
1.	80	Non-electric motors	other 4.4	29,272	59,466	192.962	582.651	5,417	96	1.015
2.	81-82	Transmissions, lifting equip.	other 4.4	14,022	33,427	74.491	170.718	2,099	161	2.392
3.	83-86	Machine tools and bits	other 4.4	11,709	23,918	55.508	147.234	3,023	560	4.976
4.	87-92	Industrial machinery	other 4.4	30,927	46,909	134.362	341.156	3,406	1,804	19.457
5.	93	Pumps, compressors, faucets	other 4.4	12,562	21,061	68.440	149.179	2,696	653	7.342
6.	94-96	Structures, furniture, safes	other 4.4	20,528	29,831	85.225	204.206	2,989	2,149	19.344
7.	97-98	Ovens, thermal machinery	4.58	10,583	15,515	46.115	109.617	3,053	554	7.435
8.	99-100	Locks, small hardware, cans	other 4.3	23,336	20,028	77.236	181.423	3,852	3,234	21.688
9.	101-104	Springs, nuts/bolts, kitchenw.	other 4.3	31,478	51,061	113.536	247.861	1,852	2,533	16.129
10.	105-110	Precision equipment	4.51/2/6	22,745	19,931	124.018	310.317	7,169	2,017	14.426
11.	111-112	Coins, medals, jewelry	4.59/10	5,844	3,498	24.153	50.097	5,000	5,253	27.732
12.	113-122	Transport equipment	4.42-45	208,900	372,939	1,120.284	2,893.180	3,702	986	14.624
13.	123-126	Electrical machinery and equip.	other 4.4	59,403	97,032	259.546	740.448	4,020	935	11.151
14.	127-131	General trades	4.31/2, 41	29,519	37,629	129.772	239.626	1,712	138,298	396.414
15.	133	Other industries	4.57	95,416	221,747	392.124	993.439	2,093	1,067	38.918

[a]non-artisanal shops with more than ten workers.
[b]million lire.
[c]lire (estimated).
[d]calculated from the reported values of goods manufactured, and materials consumed; million lire.

Sources: see text.

Table 4
The structure of the general engineering industry in 1911

row component	(1) value added (million lire)	(2) output (thous. tons)	(3) metal cons. (thous. tons)	(4) total workers (thou-sands)	(5) value added (lire) per ton of output	(6) value added (lire) per worker	(7) metal consump-tion (tons) per ton of output	(8) metal consump-tion (tons) per worker
A. Fabricated metal								
new production								
1. total	152.62	367.76	496.48	90.46	415	1,687	1.35	5.49
maintenance								
2. blacksmiths	132.68		5.24	102.69		1,292		.05
3. other smiths	53.72		.42	41.23		1,303		.01
4. other	8.65		.34	6.57		1,317		.05
5. total	195.05		6.00	150.49		1,296		.04
total								
6. total	347.67		502.48	240.95		1,443		2.09
B. General equipment								
new production								
7. mere assembly	4.25	14.18	.00	3.06	300	1,387	.00	.00
8. truss-s. comp.	14.62	41.77	50.12	5.51	350	2,651	1.20	9.09
9. other	175.30	194.78	243.48	80.34	900	2,182	1.25	3.03
10. total	194.17		293.60	88.91		2,184		3.30
maintenance								
11. total	32.86		3.79	24.69		1,331		.15
total								
12. total	227.03		297.39	113.60		1,999		2.62
C. Precision equipment: instruments								
new production								
13. total	4.57	.277	.69	1.99	16,500	2,296	2.50	.35
maintenance								
14. total	1.36		.01	.96		1,416		.01
total								
15. total	5.93		.70	2.95		2,010		.24
D. Precision equipment: clocks and watches								
new production								
16. mere assembly	1.28	.160	.00	.83	8,000	1,535	.00	.00
17. from metal	2.31	.154	.39	1.04	15,000	2,221	2.50	.38
18. total	3.59	.314	.39	1.87		1,920		.21
maintenance								
19. total	10.63		.04	6.93		1,535		.01
total								
20. total	14.22		.43	8.80		1,616		.05
Total								
21. new production	354.95		791.16	183.23		1,937		4.32
22. maintenance	239.90		9.84	183.07		1,310		.05
23. total	594.85		801.00	366.30		1,624		2.19

NB: "general engineering" excludes the shipbuilding, railway-vehicles, and precious-metal products industries.

Sources: see text.

Appendix Table 1
Physical product per engineering-industry worker, ca. 1913: firm-specific evidence

(1) Source page	(2) Firm	(3) Activity or product	(4) Workers (blue-collar)	(5) Output (tons)	(6) Sales (thousand lire)	(7) Output/ worker (tons)	(8) Horse-power/ worker
A. Fabricated metal							
152	Ghidini	small brassware	12	10		.83	.21
151	Gnutti	swords	100	100	200	1.00	.35
133	Cooperativa	hand-forged nails	500	600		1.20	.03
161	Grasselli	non-ferrous hardware	32	40	60	1.25	.05
238	Marcellino	copperware	10	13.5		1.35	
52	Toccafondi	hardware (cans)	15	26	30	1.73	.20
51	Piccinini	hardware	110	200	200	1.82	.05
32	Filosa	hardware	30	60	60	2.00	.33
153	Leali	hardware	5	10		2.00	2.00
158	Carissimo	copperware	5	10		2.00	
122	Scacchini	medals	15	40	80	2.67	.67
133	Cagnola	hardware	185	500	300	2.70	.27
158	Meroni	hardware	70	200	200	2.86	.44
138	Perego	kitchenware	120	353	600	2.94	.20
158	Monti	copperware	14	50		3.57	2.14
258	Pacini	hardware, machinery	100	391	450	3.91	1.24
188	Fornara	hardware	500	2,000	2,000	4.00	.40
310	Bellieni	hardware	25	100		4.00	.12
113	Guglieri	metal furniture	45	200	200	4.44	.07
209	Ruffoni	hardware	30	140		4.67	.50
213	Netro	tools, parts	850	4,000	4,000	4.71	.88
146	Rusconi	hardware	500	2,467	850	4.93	1.22
193	Rigaldo	tools	35	200	200	5.71	.57
194	Cooperativa	files	80	500	300	6.25	.50
271	Giorgetti	metal furniture	4	25	25	6.25	
153	Oliva	agric. tools	12	80		6.67	.42
282	Antinucci	copperware	6	40		6.67	3.33
310	Sandri	copperware	5	35		7.00	1.60
120	Pozzi	hardware	450	4,000		8.89	.67
312	FOM	hardware	30	275	275	9.17	.35
144	Mazzoleni	hardware	100	1,000	1,000	10.00	
151	Gnutti	hardware	30	300		10.00	1.67
154	Gnutti	agric. tools	14	150		10.71	1.07
258	Benti	crude tool parts	12	130		10.83	
277	Bertini	tools, machinery	50	570		11.40	1.24
213	Cremonesi	hardware	125	1,500		12.00	.80
154	Bosio	forged hardware	40	500		12.50	.88
153	Damioli	cutting tools	19	280		14.74	5.42
156	Borghi	hardware	50	750		15.00	1.00
158	Bolis	hardware	120	2,000		16.67	.92
158	Bonaiti	hardware	100	1,800		18.00	.50
63	Bolis	hardware	80	1,500		18.75	1.75
37	TPN	hardware	100	2,250		22.50	1.60
156	Panzera	hardware	40	1,000		25.00	
209	Tocco	sheet-metal prod.	12	400		33.33	.25

Appendix Table 1, cont.

(1) Source page	(2) Firm	(3) Activity or product	(4) Workers (blue-collar)	(5) Output (tons)	(6) Sales (thousand lire)	(7) Output/ worker (tons)	(8) Horse-power/ worker
B. Heavy engineering, structures							
37	Zeno	gates, stairs	50	130	130	2.60	.14
161	Carabelli	gates, stairs	15	40		2.67	.03
72	Fulconis	structures, mach.	120	391	450	3.26	.42
36	Robecchi	structures	150	750		5.00	.18
38	Cattori	structures	500	2,500		5.00	1.20
93	Migliardi	structures, mach.	110	700		6.36	.82
53	Maccaferri	structures, h'ware	300	2,800		9.33	.33
147	Togni	structures	800	8,000		10.00	.63
156	Paganoni	structures	30	300		10.00	.83
93	Marcenaro	structures, mach.	60	1,000		16.67	1.00
89	SIFGCM	pressure pipelines	350	10,000		28.57	
128	SICG	structures	150	5,000		33.33	
195	Savigliano	structures	450	18,000		40.00	
C. Heavy engineering, machinery							
110	Fornara	machinery	15	19	25	1.27	.33
266	Martelli	machinery	60	77	100	1.28	.40
112	Guerinoni	precision parts	25	39	77.5	1.56	.48
117	Monis	machinery	70	115	150	1.64	
36	SOMF	machinery, struct.	700	1,304	1,500	1.86	.29
52	Tartarini	blinds	20	38	50	1.90	.08
188	Galantini	machinery	20	38	50	1.90	.30
259	Baroncelli	machinery	12	23	30	1.92	
215	Fumagalli	machinery	80	154	200	1.93	.19
311	Gregori	machinery	40	77	100	1.93	.25
188	Frè	machinery	16	31	40	1.94	.31
208	Lizzoli	machinery	140	308	400	2.20	.29
229	BGGM	machinery	280	615	800	2.20	.29
300	Del Favero	machinery	28	62	80	2.21	1.25
30	Carrino	machinery, etc.	200	458	550	2.29	1.25
143	Paredi	machinery	16	38	50	2.38	.31
195	SMIG	precision parts	280	667	1,000	2.38	.71
197	Zanelli	machinery	150	385	500	2.57	.27
238	Tutone	machinery	60	154	200	2.57	.33
191	Mure	machinery	35	92	120	2.63	.43
106	Columbo	machinery (electric)	50	150	300	3.00	.25
292	Bedeschi	machinery	15	46	60	3.07	.25
131	Guenzani	heavy equipment	75	231	300	3.08	
167	Casali	machinery	250	769	1,000	3.08	.60
30	Carnevali	machinery (food)	65	204	265	3.14	.55
134	SAML	machinery	700	2,308	3,000	3.30	.46
124	SIIP	precision parts	75	250	500	3.33	.93
49	Calzoni	machinery	225	769	1,000	3.42	.53
192	Pistorio	safes	50	192	250	3.84	.40
215	Fumagalli	machinery	40	154	200	3.85	.25

Appendix Table 1, cont.

(1) Source page	(2) Firm	(3) Activity or product	(4) Workers (blue-collar)	(5) Output (tons)	(6) Sales (thousand lire)	(7) Output/ worker (tons)	(8) Horse-power/ worker
C. Heavy engineering, machinery (cont.)							
298	SVCMF	machinery	250	962	1,250	3.85	.25
106	Clerici	machinery (electric)	150	600	1,200	4.00	.33
147	Riunite	machinery	300	1,250		4.17	.33
58	Ferrari	machinery, struct.	30	130	150	4.33	.33
195	Savigliano	machinery	450	2,000		4.44	
186	Cigala	machinery	40	192	250	4.80	.20
110	FMA	machine parts	1,100	5,500		5.00	.82
183	Audoli	machinery	50	250		5.00	.60
183	Friulane	machinery	50	250		5.00	.24
129	Comerio	machinery	75	385	500	5.13	.53
191	Dubosc	machinery	300	1,538	2,000	5.13	.33
298	Ronfini	machinery	30	154	200	5.13	.12
128	Fregati	forged parts	20	13	90	5.65	.15
205	Cuneese	machinery, struct.	150	900		6.00	.17
51	Parenti	machinery (agric.)	300	2,000		6.67	.43
168	Moncalvi	foundry, machinery	150	1,000		6.67	
197	Westinghouse	air brakes, mach.	250	1,667	2,500	6.67	.80
251	Cacialli	machinery, struct.	37.5	250	250	6.67	.53
60	Callegari	railway equipment	90	750	750	8.33	.44
251	Bartolazzi	foundry, mach. parts	35	300		8.57	.29
93	Fossati	mach. parts (naval)	300	3,000		10.00	1.00
153	Gottardi	foundry, machinery	84	1,200		14.29	.27
168	Anelli	foundry, machinery	56	800		14.29	.20
195	Savigliano	(total)	1,800	32,500		18.06	.61
178	Trezza	foundry, machinery	176	5,000		28.41	.40
D. Heavy engineering, road vehicles							
220	Favale	bicycles, repairs	10	3		.30	1.00
137	Mona	bicycles	15	5		.33	.10
56	Ranieri	bicycles	4	2		.50	.63
103	Bianchi	bicycles, cars	1,200	650		.54	.83
113	Isotta Fras.	cars	700	600		.86	.57
202	Maina	bicycles, motorbikes	15	13.25		.88	.07
198	Bertoldo	cars, etc.	450	417	2,500	.93	.67
59	Valsit	bicycles	37	60		1.62	
305	Colli	bicycles, repairs	4	8		2.00	.50
161	Frera	bicycles	250	700		2.80	.60
132	Wolsit	cars	300	1,000	2,000	3.33	.27
131	Rejna	car parts	350	1,333	1,200	3.81	.57
131	Sessa	car parts	50	222	200	4.44	1.00
140	Silva	car parts	8	39	35	4.88	
258	Palandri	axles	20	250		12.50	

Appendix Table 1, cont.

(1) Source page	(2) Firm	(3) Activity or product	(4) Workers (blue-collar)	(5) Output (tons)	(6) Sales (thousand lire)	(7) Output/ worker (tons)	(8) Horse-power/ worker
E. Light engineering							
161	Balzaretti	watches	40	.6		.02	.13
113	Koristka	precision optics	60	4	150	.07	.50
288	Junghans	watches	300	30		.10	
150	Gardoncini	rifles	37.5	4		.11	.31
150	Cavagna	rifles	70	9.6		.14	
104	Borletti	clocks and watches	700	117.1		.17	
150	Beretta	rifles	200	48		.24	2.00
255	Verità	electrical equip.	20	13	50	.65	.15
110	Fossati	precision equip.	25	25	100	1.00	.12
140	OEB	electrical equip.	150	150	600	1.00	.11
54	Santini	electrical equip.	350	375	1,500	1.07	.17
185	Brugnoli	light equipment	12	13	50	1.08	.25
114	Larghi	electrical equip.	35	38	150	1.09	.09
114	Lesmo	precision equip.	20	25	100	1.25	.30
121	Rejna	electric lights	225	300	1,500	1.33	.53
111	Gerra	machinery (sanitary)	300	500	1,000	1.67	
266	OEL	elec. equip., etc.	150	300	600	2.00	.37
106	Comi	machinery (sanitary)	180	438	875	2.43	.22
112	Greco	electrical, artistic	115	400	800	3.48	.61
136	Cusano	kitchen stoves	25	100	100	4.00	.24

Source: see text.