Analyses of Business Dissolution by Demographic Category of Business Ownership *

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Executive Summary

How do the survival prospects of new businesses vary across demographic (racial, ethnic, and/or gender) categories of business ownership? Some light has been shed on this matter by a few studies based on the Census Bureau's 1982, 1987, and 1992 Characteristics of Business Owners (CBO) cross-sectional data series. But the CBO data are limited in their ability to entertain such inquires, and other studies on this subject have used data of questionable quality and robustness.

All this has changed with the creation of a unique and valuable longitudinal data series. While at the Office of Advocacy of the U.S. Small Business Administration, Dr. Alicia Robb (now an economist with the Federal Reserve Board of Governors) matched the Census Bureau's 1992 Survey of Minority-Owned Business Enterprises (SMOBE) and 1992 Women-Owned Businesses survey data with the 1989-1996 Business Information Tracking Series (BITS). The BITS is an annual, longitudinal database containing data on nearly all U.S. businesses and establishments with positive payrolls. It is now possible to examine a wide variety of longitudinal inquiries over the 1992-1996 time period by gender, race, and/or ethnicity of a business' ownership status.

This study uses the matched SMOBE-WOB-BITS data to examine the survival prospects of business started in 1992 for four different, mutually exclusive classifications of business ownership–-namely, White, non-Hispanics; White, Hispanics; Blacks; and Asian and other minorities. Regression-like proportional hazard models were specified and estimated to produce insight into the ceteris paribus impact of certain business, industry, and geographic characteristics on businesses' risk of dissolution over the 1992-1996 time period. These models were estimated separately for each of the aforementioned ownership categories as well as for data pooled across those ownership categories.

In addition to these statistical analyses, some descriptive information was also extrapolated from these data. For instance:

- For all businesses (with positive payrolls in the re-weighted matched sample) that were started in 1992, 47 percent survived until at least 1996.
- The 1992-1996 survival rate for new, White, non-Hispanic owned businesses was 48.7 percent.
- The 1992-1996 survival rate for new, Black owned businesses was 34.7 percent.
- The 1992-1996 survival rate for new, White, Hispanic owned businesses was 44.9 percent.
- For businesses started in 1992 by Asians and other minorities, the 1992-1996 survival rate was 50.4 percent.

For eating and drinking places (with positive payrolls) that were started in 1992:

- 44.8 percent of all businesses survived through 1996;
- 45.6 percent of businesses owned by White, non-Hispanics survived through 1996;
- 35.6 percent of businesses owned by Blacks survived through 1996;
- 41.2 percent of businesses owned by White, Hispanics survived through 1996;
- 47.1 percent of businesses owned by Asians and other minorities survived through 1996.

And for business services firms (with positive payrolls) that were started in 1992:

- 43.7 percent of all businesses survived through 1996;
- 47.6 percent of businesses owned by White, non-Hispanics survived through 1996;
- 18.5 percent of businesses owned by Blacks survived through 1996;
- 49 percent of businesses owned by White, Hispanics survived through 1996;
- 59.9 percent of businesses owned by Asians and other minorities survived through 1996.

In light of these latter figures, it appears that cross-demographic differences in business survival rates can vary considerably by major industry group.

The **top five major industry groups (2-digit SICs) in terms of 1992-1996 survival rates** for employer firms started in 1992 were calculated for each of the four demographic categories of business ownership. In descending order, the top five industry groups for White, non-Hispanic owned businesses were:

- Oil and Gas Extraction (81.7-percent survival rate);
- Electric, Gas, and Sanitary Services (76.6-percent survival rate);
- Measuring, Analyzing, and Controlling Instruments (76.4-percent survival rate);
- Fabricated Metal Products (except Machinery and Transportation Equipment) (71.5-percent survival rate);
- Health Services (69.6 percent survival rate).

For Black owned businesses, the top five major industries were:

- Legal Services (79.1-percent survival rate);
- Social Services (66.4-percent survival rate);
- Real Estate (57.0-percent survival rate);
- Insurance Agents, Brokers, and Service (56.2-percent survival rate);
- Miscellaneous Retail (54.1-percent survival rate).

For White, Hispanic owned businesses, the top five major industries were:

- Health Services (65.6-percent survival rate);
- Legal Services (58.4-percent survival rate);
- Construction Special Trade Contractors (58.1-percent survival rate);
- Automotive Dealers and Gasoline Service Stations (54.7-percent survival rate);
- Wholesale Trade - Durable Goods (54.6-percent survival rate).

For businesses owned by Asians and other minorities, the top five industries were:

- Health Services (76.3-percent survival rate);
- Legal Services (71.8-percent survival rate);
- Hotels, Rooming Houses, Camps, and Other Lodging Places (68.5-percent survival rate);
- Business Services (59.9-percent survival rate);
- Wholesale Trade - Durable Goods (57.9-percent survival rate).

Note that the three demographic categories of ownership other than White, non-Hispanic, the top five 2-digit SIC industries in terms of 1992-1996 survival are predominantly in the service-producing sector. By contrast, three of the top five 2-digit industries for White, non-Hispanic owners are in the goods-producing sector.

A good portion of the text of this report is devoted to interpretation of estimated hazard ratios from proportional hazard models. It is difficult to summarize the findings of these models here. This is because the estimated, ceteris paribus hazard ratios vary by covariate and owners' demographic category in both magnitude and statistical significance. Consequently, few broad statements can be made across racial categories of ownership on the influence of, for instance, a business' industrial or geographic location on their hazard or risk of dissolution. As an example of this heterogeneity, White, non-Hispanic owned businesses in the manufacturing industry division have an estimated hazard of dissolution that is 34.5 percent higher, other things equal, than White, non-Hispanic owned businesses in agricultural services and mining. Yet, Black owned manufacturing firms have only 63.7 percent of the risk of dissolution that of Black owned agricultural services and mining businesses, other things equal. And for businesses owned by White, Hispanics and Asians and other minorities, the estimated hazard ratio for the manufacturing dummy covariate is not statistically significant.

The proportional hazard models that were estimated for two heavily populated major industry groups–eating and drinking places and business services–yielded provocative results. For eating and drinking places, incorporated businesses for each demographic category of ownership were at an estimated, ceteris paribus risk of dissolution that was statistically significant and substantially lower than their unincorporated counterparts. But that is pretty much where the uniformity ceases. For example, the estimated hazard rate for eating and drinking places located in the South census region were statistically significant for each of the four demographic categories of ownership, but varied dramatically in magnitude across those categories. More specifically, compared to the North Central (reference) census region, businesses owned by White, non-Hispanics and Asians and other minorities had ceteris paribus hazards of dissolution that were respectively 38 and 39 percent higher, other things equal. Eating and drinking places owned by White, Hispanics had a hazard of dissolution that was over twice that of their counterparts located in the North Central census region, other things equal. In contrast, however, Black owned businesses in the South census region had a ceteris paribus hazard of dissolution that was just 28 percent that of Black owned eating and drinking places located in the North Central census region.

For the business services major industry group, incorporated businesses once again had an estimated, ceteris paribus risk of dissolution that was statistically significant and substantially lower than their unincorporated counterparts for each demographic category of ownership. Business services firms located in MSAs had estimated hazards of dissolution that were statistically significant and substantially higher than firms not located in MSAs for three of the four racial categories of ownership. White, non-Hispanic business services firms located in MSAs had an estimated hazard of dissolution that was 41 percent higher than their counterparts located outside of MSAs, and Black owned businesses located in MSAs had an estimated 92-percent higher hazard of dissolution than their non-MSA counterparts. Business service firms owned by Asians and other minorities had an estimated hazard of dissolution that was, other things equal, about *3.7 times greater* than their counterparts not located in MSAs.

The preceding discussion provides a mere glimpse at the findings drawn from the multivariate BITS data that are presented in this report. Tables presenting estimated hazard ratios for all proportional hazard models of business dissolution can be found in the text of the report. In short, though, multivariate analyses of business dissolution using the BITS data are at once more telling and more puzzling when conducted at the 2-digit level, especially if one is concerned with the demographic status of businesses' ownership. But if one ***is*** concerned with demographic category of ownership, the matched SMOBE-WOB-BITS is the easily the best source of descriptive information on U.S. business dynamics, such as employment change and births and deaths. It may be that multivariate analyses of these data raise more questions than they can currently resolve, but then, the matched SMOBE-WOB-BITS data can be fairly easily augmented by matching data from other sources at various levels of geographic and industrial detail. And in any case, multivariate analyses of the matched data, particularly when conducted for more specific industry definitions, such as major industry groups, should provide voluminous fodder for follow-up inquiries.

I. Introduction

Using a unique, matched data series, this study focuses on the determinants of the dissolution of businesses started in 1992--over the 1992-1996 time period--by businesses' demographic category of ownership. This data series consists of the 1989-1996 Business Information Tracking Series (BITS) matched with the 1992 Survey of Minority-Owned Business Enterprises (SMOBE) and 1992 Women-Owned Businesses (WOB) data series.[1] These data series were matched and re-weighted by Dr. Alicia Robb, now with the Federal Reserve Board, while she was employed by the Office of Advocacy of the U.S. Small Business Administration (SBA). This matched file allows longitudinal analyses of businesses by gender and demographic category of ownership.

All data analyses in this study are broken out into four mutually exclusive demographic categories of ownership: White, non-Hispanic; Black (including Hispanic); White, Hispanic; and Asian and other races (including Hispanic).[2] In multivariate analyses, dummy variables are used to control for gender. There have been other, analogous analyses of the determinants of business dissolution/survival, notably Mata and Portugal (1994) and Audretsch and Mahmood (1995), but none has been broken out by demographic category of ownership.

[1]The BITS is a product of the U.S. Bureau of the Census and was sponsored by and designed with input from the SBA's Office of Advocacy. The SMOBE and WOB series are also produced by the Census Bureau as part of their quinquennial economic censuses.

[2]The demographic classifications invoked in this study differ from the U.S. Bureau of the Census' standard classification system in that, under their classification system, *all* Hispanics, including Black Hispanics, Asian Hispanics, and other minorities with Hispanic lineage are included in the Hispanic demographic category.

II. Data

The BITS is a database containing longitudinal data on virtually all non-farm U.S. business establishments with paid employees.[3] Funded by the Office of Advocacy of the U.S. Small Business Administration (SBA) and developed with the cooperation of the U.S. Bureau of the Census, the BITS currently spans 1989 through 1997 at annual intervals. The unit of analysis in the BITS is the individual establishment. However, these data permit aggregation of dependent establishments into firms defined as either Employer Identification Numbers (EINs) or Census File Numbers (CFNs). Variables in the BITS include: establishment employment; firm employment; standard industrial classification (SIC) code; geographic identification codes for state, metropolitan statistical area (MSA), and county; establishment payroll; establishment start year; and, as previously noted, codes permitting linkage of members of multi-establishment firms.[4]

The BITS is unique among longitudinal business/establishment databases in its coverage of nearly all U.S. industries. To date, virtually all studies based upon longitudinal business databases have been restricted to the manufacturing industry because suitable data were only available for that industry.[5]

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[3]The BITS excludes businesses owned by self-employed individuals who have no paid employees. Employment in the BITS is measured as of the March 12 payroll period. Thus establishments that close before that date, start thereafter, or operate seasonally are included in this data series for any given year, but will have a reported employment of zero for that year.

[4]For more complete documentation of the contents and construction of the BITS, see Robb (1999).

[5]Development of the BITS was an initiative of the SBA, whose constituency includes businesses in all industries, if not predominantly those outside the manufacturing industry. The SBA needed a source of data that would allow for tabulations of employment change by firm size and industry, and turned to the vast data resources of the Census Bureau.

The SMOBE and WOB are cross-sectional data series produced every five years as part of the Census Bureau's economic censuses. The SMOBE and WOB universe is comprised of sole proprietorships, partnerships, and S corporations (small corporations). These data series contain information on businesses' demographic category of ownership: in 1992, race and gender of the "majority" of firms' respective owners were obtained through a mail survey. For those select sole proprietors that filed federal income tax form Schedule 1040 SE, the Census Bureau used the Social Security number on this form to identify owner's gender.

The SMOBE and WOB also contain data on several firm characteristics, including industry, geographic location, employment, payroll, and receipts. These two files also contain weights that permit calculation of population estimates of businesses by demographic and gender category of ownership. According to Robb (2000), the weighted SMOBE and WOB data represent some 17 million firms, of which 3.1 million had positive payrolls in 1992.

Robb matched the 1992 SMOBE and 1992 WOB data to the 1989-1996 BITS using EINs. Since the BITS universe consists of firms with positive payrolls in a given year, Robb matched only that corresponding portion of the SMOBE and WOB to the BITS. In short, the unit of analysis in the matched file is the EIN. As Robb (2000, p. 48) notes:

> "A firm can have one or more EINs and each EIN can consist of one or more establishments. Most firms have just one EIN with just one establishment, but some have many EINs, each having many establishments. For [her purposes], the BITS file [data were] aggregated up to the EIN level and the SMOBE [and WOB] data was merged onto the BITS by EIN."[6]

[6]Details of the file-matching and re-weighting process can be found in Appendix C of Robb (2000).

Remarkably, Robb was able to match all but 6 percent of the employer firms in the 1992 SMOBE and WOB files with the BITS. She then created a new set of weights to adjust for unmatched EINs. Her matched file allows for longitudinal analyses--such as employment change and firm survival--by demographic category of ownership that are potentially of unprecedented detail and accuracy. However, there is one notable limitation of the matched SMOBE-WOB-BITS data. Demographic information on ownership status is only available for 1992. It is possible for firms to change ownership over the 1992-1996 period, and thus experience changes in demographic ownership status. When the 1997 BITS, SMOBE, and WOB data become available, it will become possible to shed some light on the magnitude of this phenomenon.

The data analyses reported in this study were confined to firms in the matched SMOBE-WOB-BITS file that were started in 1992 (as indicated by the start-year variable in the BITS). This subset of the matched file is comprised of 44,707 unweighted observations (EINs).

III. The Five Major Industry Groups (2-digit SICs) with the Highest 1992-1996 New Firm Survival Rates by Demographic Category of Ownership

Tabulations of the matched SMOBE-WOB-BITS data were performed to determine, by demographic category of ownership, which major industry groups (2-digit SICs) had the highest 1992-1996 new (in 1992) business survival rates. These tabulations appear in Table 1. Note that the figures in Table 1 pertain only to major industry groups populated by 50 or more firms started in 1992. Although this exact criterion is somewhat subjective, inclusion of more sparsely populated industries in these tabulations would yield spurious results.

Table 1. Top Five Major Industries in Terms of 1992-1996 Business (EIN) Survival Rates By Demographic Category of Ownership

White, Non-Hispanic Owned		
Major Industry Name	**SIC Code**	**Survival Rate (%)**
Oil and Gas Extraction	13	81.69
Electric, Gas, and Sanitary Services	49	76.61
Measuring, Analyzing, and Controlling Instruments	38	76.36
Fabricated Metal Products (exc. Machinery and Transportation Equip.)	34	71.50
Health Services	80	69.55
Black Owned		
Major Industry Name	**SIC Code**	**Survival Rate (%)**
Legal Services	81	79.11
Social Services	83	66.42
Real Estate	65	57.00
Insurance Agents, Brokers, and Service	64	56.24
Miscellaneous Retail	59	54.10
White, Hispanic Owned		
Major Industry Name	**SIC Code**	**Survival Rate (%)**
Health Services	80	65.60
Legal Services	81	58.43
Construction Special Trade Contractors	17	58.06
Automotive Dealers and Gasoline Service Stations	55	54.71
Wholesale Trade - Durable Goods	50	54.60
Asian/Other Owned		
Major Industry Name	**SIC Code**	**Survival Rate (%)**
Health Services	80	76.33
Legal Services	81	71.83
Hotels, Rooming Houses, Camps, and Other Lodging Places	70	68.52
Business Services	73	59.90
Wholesale Trade - Durable Goods	50	57.90

*** Note: Data pertain exclusively to new (in 1992) firms (EINs) with positive payrolls in 1992. Also, in order to be included in this tabulation, a major industry must have had at least 50 new firms (EINs) in 1992.**

Source: Special Tabulations of 1992-1996 BITS data matched with 1992 SMOBE and WOB data. This merged data series was created by Dr. Alicia Robb of the Federal Reserve Board of Governors while she was employed by the Office of Advocacy of the U.S. Small Business Administration.

The numbers presented in Table 1 are self-explanatory. However, some commentary is warranted. The major industry groups with the highest survival rates for businesses owned by demographic groups other than White, non-Hispanics are predominantly within the services industry division, and none of these major industry groups are in the goods-producing sector. In contrast, four of the five major industry groups with the highest 1992-1996 survival rates for White, non-Hispanic are in the goods-producing sector. So, there appears to be a systematic difference between minority and non-minority owned firms represented in the roster of industries with the highest 1992-1996 survival rates in terms of capital intensity.

Health Services and Legal Services major industry groups are generally well represented among the top five 2-digit industries in terms of 1992-1996 survival rate. Health Services is no doubt largely comprised of firms associated with primary health-care providers--i.e., physicians, dentists, etc.

Among minority owned businesses, a few "surprises" emerged. For instance, Construction Special Trade Contractors and Automotive Dealers and Gasoline Service Stations made the list of highest 1992-1996 business-survival-rate major industry groups for White, Hispanic owned businesses. This is unique among the four demographic categories of ownership. And Hotels, Rooming Houses, Camps, and Other Lodging Places uniquely made the list of 2-digit SIC industries with the highest 1992-1996 survival rates for businesses owned by Asians and other minorities.

IV. Multivariate Analyses of 1992-1996 Survival of Firms Started in 1992 by Demographic Category of Business Ownership across Industries

In this section, the determinants of business dissolution by demographic category of ownership are examined using a special technique for analyzing survival data. This technique is known as *proportional hazard modeling*, and yields regression-like results.[7] In this context, a hazard rate is the probability that a firm will close in the next time interval, $t + \delta$ (as δ approaches zero), given that it has survived until time t.[8] The unit of analysis for all hazard models reported in this study is the firm (EIN), and only firms with a 1992 start year (determined from BITS information) are included in these models. The "dependent variable" in these models is survival time in years.

A. Model Specification

Proportional hazard models with covariates were estimated--using SAS PROC PHREG--separately for each of four demographic categories of business ownership, as well as for data pooled across those four categories. Most of the covariates in these models are dummies corresponding to location (MSA status and census division (cdiv)), industry division, legal form of organization, gender classification of ownership, and--in the case of the model estimated for firms of all ownership categories--race/gender interaction variables. Continuous covariates include:

[7] Among other things, the right-censoring of the data--the fact that it is impossible to know when firms that survived through 1996 will ultimately dissolve--precludes the use of conventional regression techniques. See Appendix A for a more detailed, technical description of this statistical methodology.

[8] In this study, a firm (EIN) is considered to be closed in year t + n if it has zero employment in year n and all subsequent years.

initial (1992) EIN (firm) employment;

number of establishments started in 1992, calculated at the census division and 2-digit SIC level from the full 1992 BITS panel;

number of dependent establishments in 1992, calculated at the census division and 2-digit SIC level from the full 1992 BITS panel;

total number of establishments in 1992, calculated at the census division and 2-digit SIC level from the full 1992 BITS panel;

mean establishment employment in 1992, calculated at the census division and 2-digit SIC level from the full 1992 BITS panel;

variance in establishment employment in 1992, calculated at the census division and 2-digit SIC level from the full 1992 BITS panel; and

percent of 1992 population that's comprised of a given race, calculated at the census division level. (For example, for Black owned EINs, this variable equals the estimated percent of people who are Black in the respective census divisions in which those EINs are located.)

The variables calculated at the census division and 2-digit SIC level using the full 1992 BITS panel were specified to further control for industry and regional effects. For instance, the mean and variance in employment were specified as proxies for scale effects. It was hypothesized that industries and census divisions with larger mean establishment employment levels would reflect environments characterized by higher minimum efficient scales (MESs) and, thus, greater entry barriers and lower new firm survival prospects, other things equal. By contrast, industries and census divisions with larger variances in establishment employment were hypothesized to reflect environments with lesser degrees of scale economies, lower entry barriers, and greater prospects for new firm survival.

The "population percent" variable was specified to assess how regional variations in the 1992 demographic composition of populations affects firms' relative risks of dissolution. A naive hypothesis regarding this variable is that, for example, Black owned businesses would be at lower risk of dissolution in census divisions with higher proportions of Black people, other things equal.

B. Estimation Results

Table 2 shows the estimated hazard ratios for assorted covariates by demographic category of ownership, as well as for all demographic categories.[9] But before we delve into interpretation of these hazard ratios, we can examine the actual proportion of firms in each demographic category of ownership that survived from 1992 through 1996.[10] According to Table 2, 48.7 percent of White, non-Hispanic owned businesses that were started in 1992 managed to survive through 1996. For Black owned firms started in 1992, the 1992-1996 survival rate was 34.7 percent. For White, Hispanic owned businesses started in 1992, the corresponding survival rate was 44.9 percent, and for businesses started in 1992 by Asians and other minorities, the corresponding survival rate was 50.4 percent. The survival rate for all businesses started in 1992 was 47.0 percent.

[9] In addition to hazard ratios, PROC PHREG also provides the actual proportional hazard model parameter estimates and corresponding Chi-squared values for determining the statistical significance (p-value) for these estimates. The parameter estimates are, in fact, equal to the natural logarithms of the corresponding hazard ratios. Since the hazard ratios have a more intuitive interpretation than their corresponding parameter estimates, only the hazard rates (and assorted model Chi-squared test statistics) are reported in Table 1.

[10] All data analyses reported for this study made use of Robb's adjusted weights normalized so as to sum to unity within a given reference group.

The interpretations of the estimated hazard ratios reported in Table 2 vary between dummy and continuous covariates, and are best explained through examples. Below is a general interpretation of the estimated hazard ratios, followed by a more systematic evaluation of these ratios.

For continuous covariates, the hazard of dissolution--the ceteris paribus probability that a firm will close in the next infinitesimally short time interval--equals 100 * (hazard ratio - 1). For example, the hazard ratio for the "population percent" variable for Black owned businesses equals 1.067 and is statistically significant. This means that for every one-percent increase in the percent of a census division's 1992 population that is Black, Black owned businesses in that census division have a 6.7 percent higher hazard of dissolution, other things equal. As another example, for every unit (one-employee) increase in mean establishment employment size (calculated at the 2-digit SIC and census division level), Asian owned businesses' hazard of dissolution equals -0.6 percent, other things equal. That is, for every *employee* increase in mean establishment employment size calculated at the 2-digit SIC and census division level, Asian owned businesses' hazard of dissolution declines by 0.6 percent, other things equal.[11]

[11]This may seem small, but put into perspective, every ten-employee increase in mean establishment employment size--calculated at the 2-digit SIC industry and census division--results in a 6-percent lower hazard of dissolution for Asian and other minority owned firms.

Table 2. Estimated Hazard Ratios for Business Started in 1992 by Demographic Category of Ownership.

	Hazard Ratios				
Covariate Description	**White, Non-Hispanic Owned**	**Black Owned**	**White, Hispanic Owned**	**Asian/Other Owned**	**All Races**
1992 EIN employment	1.000	0.995	1.000*	0.999	1.000
Dummy: incorporated EIN	0.703	0.530*	0.655	0.628*	0.701*
Dummy: large MSA-central city	1.067	1.262*	0.901	0.901	1.031
Dummy: large MSA-inner suburbs	1.114*	1.339*	0.819	0.927	1.055**
Dummy: large MSA-outer suburbs	1.066**	1.294*	0.939	1.167**	1.117*
Dummy: medium MSA	1.065*	1.286*	0.945	1.054	1.088*
Dummy: small MSA	0.949	1.065	0.980	0.854	0.960
Dummy: construction	1.106**	1.093**	0.871	1.965*	1.134*
Dummy: manufacturing	1.345*	0.637*	0.962	1.209	1.130**
Dummy: T.C.P.U.	1.366*	0.558*	1.012	1.679*	1.166
Dummy: wholesale trade	1.021	0.186*	0.786	1.274	0.829*
Dummy: retail trade	0.960	0.248*	0.751*	1.302**	0.820*
Dummy: F.I.R.E.	1.116*	0.428*	0.847	1.453*	1.009
Dummy: services	1.049	0.610*	1.013	1.017	0.955
Dummy: east south central	1.082**	0.522*	1.047	1.406	1.174*
Dummy: middle atlantic	0.934**	0.514*	0.929	1.011	0.931*
Dummy: south atlantic	0.958	0.369	1.191	1.154**	1.010
Dummy: west north central	0.991	1.272	1.003	1.188	1.099*
Dummy: west south central	0.891*	0.653	0.884**	0.915	0.921*
Dummy: woman-owned EIN	1.077*	0.954	1.099	1.086**	1.086*
# of 92 starts by cdiv & sic2	1.000	1.000*	1.000	1.000	1.000*
# of dep. estabs. by cdiv and sic2	1.000*	1.000*	1.000*	1.000*	1.000*
# of estabs. by cdiv and sic2	1.000*	1.000*	1.000*	1.000*	1.000*
Mean estab. emp. in 92 by cdiv and sic2	0.997**	0.999	1.000	0.994*	0.998**
Variance in estab. emp in 92 by ...	1.000	1.000*	1.000**	1.000*	1.000*
92 percent of pop. total by race and cdiv	1.003*	1.067*	0.991	0.999	0.999
Dummy: black-owned EIN					1.289*
Dummy: hispanic-owned EIN					1.067
Dummy: asian/other-owned EIN					0.909
Dummy: black woman-owned EIN					0.836*
Dummy: hispanic woman-owned EIN					1.067
Dummy: asian/other woman-owned EIN					0.938
* underlying coefficient is significant with a "p-value" ≤ 1 percent; ** underlying coefficient is significant with a "p-value" ≤ 5 percent					
Number of Observations	27,180	5,357	3,839	8,331	44,707
Percent of EINs Surviving to 1996	48.7	34.7	44.9	50.4	47.0
	Model Chi-Squares				
Likelihood-Ratio Test Statistics	681.743	728.168	185.887	540.423	1,762.900
Score Test Statistics	673.198	676.757	191.870	524.790	1,739.166
Wald Test Statistics	668.136	634.574	188.252	509.395	1,716.212

Note: Data pertain exclusively to new (in 1992) firms (EINS) with positive payrolls in 1992.

Source: Special Tabulations of 1992-1996 BITS data matched with 1992 SMOBE and WOB data. This matched data series was created by Dr. Alicia Robb of the Federal Reserve Board of Governors while she was employed by the Office of Advocacy of the U.S. Small Business Administration.

For dummy variables, the hazard ratios measure the hazard of dissolution relative to a given reference group--i.e., a group not represented by other dummy variables specified in the model--other things equal. Again, the interpretation of these hazard ratios is best explained through examples. Consider the hazard ratio for Black owned businesses that are incorporated. The hazard ratio for incorporated Black owned businesses is 0.530, meaning that Black owned businesses that are incorporated are at only just over one-half (53 percent) of the hazard of dissolution relative to their unincorporated counterparts, other things equal.

Now, some dummy covariates correspond to polychotomous variables, such as census divisions, of which there are nine in total. In the models estimated separately by demographic category of ownership, only five of nine dummy variables for census divisions are specified.[12] Similarly, dummy covariates for some industry divisions were excluded from the specification of these models, and, for the various MSA categories, the excluded category pertains to businesses not located in MSAs.[13]

[12]Four census divisions were not specified as covariates, largely due to the Census Bureau's disclosure rules. These census divisions are New England, Mountain, Pacific, and East North Central. The model estimated with data for firms across racial category of ownership did include dummy covariates for the New England and Mountain census divisions, although the hazard ratios for these covariates are not reported.

[13]Industry dummies not included in these models pertain to agricultural services and mining.

One might well ask "What is the hazard of dissolution in one census division vs. another?" Or "How does the hazard of dissolution of manufacturing firms compare to that of firms in the services industry division?" Suppose, for example, we want to determine the difference between the hazard rate of White, non-Hispanic owned firms located in the Middle Atlantic census division and that of their counterparts in East South Central census division. We would divide the hazard ratio for the Middle Atlantic covariate by the hazard ratio of the East South Central census division to get 0.943/1.082 = 0.863. This means that, other things equal, firms located in the Middle Atlantic census division have 86.3 percent of the hazard of dissolution that firms in the East South Central census division have.

Of course, a calculator isn't needed to draw inferences from the estimated hazard ratios. Estimated hazard ratios for dummy covariates corresponding to polychotomous variables can be used to rank characteristics in terms of their respective, ceteris paribus hazards of dissolution. Consider, for example, White, non-Hispanic owned businesses. Of the seven industry divisions specified as dummy covariates, other things equal, firms in the transportation, communications, and public utilities (T.C.P.U.) industry division have the highest hazard of dissolution, while firms in the retail trade industry division have the lowest hazard of dissolution.

Initial Firm Employment Size (1992 EIN Employment)

One might logically expect that the more employees that a firm has when it starts, the better its survival prospects are. However, the hazard ratio for initial employment size is not statistically significant for the full sample, nor is it significant for three of the four demographic categories of

ownership (and isn't numerically significant for the other). This finding is curious and warrants further investigation.[14]

Incorporated Status

For all demographic categories of ownership, estimated hazard ratios for firms that were incorporated (S-corporations) indicate that incorporated firms have a substantially lower hazard of dissolution. However, the estimated hazard ratio for this covariate is not statistically significant for businesses owned by White, non-Hispanics and Asian owned businesses.

MSA Status

When the underlying parameter estimates for the various MSA dummy covariates are significant (and *none* are significant for White, Hispanic-Owned Businesses), they indicate higher hazards of dissolution for firms located in MSAs compared to firms not located in MSAs. These findings are consistent with Robb (2000) and Boden (2000), who report similar results.

Industry

The hazard ratios associated with the seven industry dummy covariates specified in these models vary substantially in magnitude and statistical significance across the four ownership categories, and there are no apparent, systematic patterns. Once again, these ratios can be directly

[14]Closer examination of the 1992 employment data revealed that an unexpectedly large number of firms with a 1992 start date had zero employment in 1992, albeit positive payrolls. Of course, as previously noted, employment in the BITS is measured as of the March 12 payroll period. Thus establishments that close before that date, start thereafter, or operate seasonally are included in this data series for any given year, but will have a reported employment of zero for that year.

compared to the reference group of industries (agricultural services and mining) not represented as covariates in the models. Within industry divisions, there is still considerable variation in types of businesses, although one can probably safely assume that manufacturing industries are generally more capital-intensive and have higher entry barriers than retail trade and service industries. (The next section of this paper examines two particular 2-digit SIC industries--viz., eating and drinking places and business services.)

Census Division

As was the case with industry, the magnitude of the estimated effects (and statistical significance) of the geographic location (census division) of firms are quite mixed across the four demographic categories of ownership. Again, these hazard ratios for the census division covariates can be directly compared the four census divisions (New England, Mountain, East North Central, and Pacific) not specified as covariates in the models. White, non-Hispanic owned businesses have a substantially lower hazard of dissolution in the West South Central census division, other things equal. Black owned businesses have especially lower hazards of dissolution in the East South Central and Middle Atlantic census divisions. For White, Hispanic owned businesses, the only census division covariate with a statistically significant hazard of dissolution is the West South Central census division, where the hazard of dissolution is also the lowest among these firms. For Asian and other minority owned firms, there is also only one census division--in this case, the South Atlantic census division--where firms' hazard of dissolution is statistically significant. This is also one of the census divisions with the highest hazard of dissolution for these businesses.

Gender

The hazard of dissolution for women owned businesses is not statistically significant for Black owned and White, non-Hispanic owned businesses. However, women owned businesses are at 7.7-percent and 8.6-percent greater hazards of dissolution, other things equal, among White, non-Hispanic owned and Asian and other minority owned businesses, respectively.

Industry/Regional Characteristics

As previously noted, five covariates--calculated from the full 1992 BITS panel--were specified to summarize the respective business environments at the 2-digit SIC and census division level. Across ownership categories, with the exception of the number of 1992 establishment starts, the hazard ratios for these covariates are statistically significant. But the numerical effects of these covariates, with a couple of exceptions, are negligible. These exceptions are as follows. For White, non-Hispanic owned businesses, every unit (employee) increase in mean establishment employment size in 1992 (calculated at the 2-digit SIC and census division level) results in a 0.3-percent decrease in hazard of dissolution, other things equal. For Asian owned businesses, every unit (employee) increase in mean 1992 establishment employment size (similarly calculated) results in a ceteris paribus decrease of 0.6-percent in hazard of dissolution.

It should be noted that inclusion of these five covariates did appear to improve control for industry and regional effects. Models of a similar specification were also estimated by demographic category of ownership **without** these covariates, and in these models, many more of the estimated hazard ratios associated with industry and census division were statistically significant, especially

for non-Black owned businesses.[15] This suggests that these five covariates calculated from the full 1992 BITS panel are correlated with the industry division and census division dummies specified as covariates in the models, and the exclusion of these five covariates would likely result in biased estimated hazard ratios for these dummy covariates.

Demographic Composition by Census Division

The demographic composition of the census divisions in which businesses are located only has a statistically significant, ceteris paribus impact on firms' estimated hazard of dissolution for White, non-Hispanic owned businesses and Black owned businesses. For White, non-Hispanic owned businesses, every one-percent increase in the percent of the people in the census division in which a firm is located who are white results in an estimated 0.3-percent increase in the hazard of dissolution, other things equal. For Black owned businesses, every one-percent increase in the percent of the people in the census division in which a firm is located who are Black results in a considerably more substantial 6.7 percent increase in their estimated hazard of dissolution.

II. Multivariate Analyses of 1992-1996 Survival of Firms Started in 1992 by Demographic Category of Business Ownership: A Look at Two Major Industry Groups

In this section, the determinants of new (in 1992) businesses' hazard of dissolution are examined for two different major industry groups: eating and drinking places (SIC 58) and business services (SIC 73). These two major industry groups were selected because they were among the most heavily populated by new firms (in 1992) in each of the four demographic categories of

[15]The estimation results for these models, while not reported in this study, are available from the author.

ownership. Again, proportional hazard models for each of these two industries were estimated separately for each of the four ownership categories. In addition, models were estimated with data pooled across observations on firms in all ownership categories. The estimation results are summarized in Tables 3(a) and 3(b), below.

A. Model Specification

The covariates in each of these models include initial (1992) firm (EIN) employment size, and dummy covariates for incorporated status, MSA location status, gender of ownership, as well as dummy covariates for each of three of the four census *regions*. Also, a covariate was specified for the percent of each of nine census divisions' population that is comprised of a given race. This covariate is the same as that which was specified as a covariate in the models discussed in the previous section of this report. For models estimated with data pooled across observations on firms in all ownership categories, dummy covariates for demographic category of ownership (excluding the White, non-Hispanic owned reference category) were also specified.

B. Estimation Results for Eating and Drinking Places (SIC 58)

As Table 3(a) reports, the proportion of eating and drinking places that were started in 1992 and survived through 1996 equals 44.8 percent, overall, and 45.6 percent for White, non-Hispanic owned firms, 35.6 percent for Black owned firms, 41.2 percent for White, Hispanic owned firms, and 47.1 percent for firms owned by Asian and other minorities. A systematic evaluation of the estimates for the covariates in the proportional hazard models follows.

Initial Firm Employment Size (1992 EIN Employment)

For eating and drinking places owned by White, non-Hispanics and Asians and other minorities, the estimated hazard ratios associated with initial (1992) EIN employment size are neither numerically nor statistically significant. However, every one-employee increase in initial firm employment size results in an estimated 2.6-percent decrease in Black owned businesses' hazard for dissolution, other things equal, and an estimated 5.3-percent decrease in White, Hispanic owned businesses' hazard for dissolution, other things equal.

Incorporated Status

For eating and drinking places in all four demographic categories of ownership, S corporations are at a substantially lesser hazard of dissolution--both numerically and statistically--than their unincorporated counterparts. Incorporated Black owned businesses and businesses owned by Asians and other minorities each have an estimated, ceteris paribus hazard of dissolution that equals 51.6 percent that of proprietorships and partnerships. Incorporated White, non-Hispanic owned businesses have an estimated hazard of dissolution that is 64.4 percent that of their unincorporated counterparts, other things equal. Finally, White, Hispanic owned businesses organized as S corporations have an estimated hazard of dissolution that equals 55.3 percent that of their unincorporated counterparts, other things equal.

Table 3(a). Estimated Hazard Ratios for Firms (EINs) Started in 1992 in the Eating and Drinking Places Industry (SIC 58) by Race of Ownership

	Hazard Ratios				
Covariate Descriptions	**White, Non-Hispanic Owned**	**Black Owned**	**White, Hispanic Owned**	**Asian/Other Owned**	**All Races**
1992 EIN employment	1.000	0.974**	0.947*	0.999	1.000
Incorporated EIN	0.644*	0.516*	0.553*	0.516*	0.618*
dummy: MSA	0.928	1.474	0.732	0.737*	1.013
dummy: northeast census region	1.687*	0.219*	1.756	0.917	0.890
dummy: south census region	1.377*	0.282*	2.131*	1.391*	1.174**
dummy: west census region	1.297	0.783	1.681	1.499	0.882
dummy: woman-owned EIN	1.352*	0.745**	1.416**	1.105	1.166*
92 percent of pop. total by race and creg.	1.016*	1.118*	0.978	0.958**	1.011*
dummy: black-owned EIN					2.223*
dummy: hispanic-owned EIN					1.979*
dummy: asian/other-owned EIN					1.906*
* underlying coefficient is significant with a "p-value" of ≤ 1 percent; ** underlying coefficient is significant with a "p-value" of ≤ 5 percent					
Number of Observations	1,745	373	396	1,363	3,877
Percents of EINs Surviving to 1996	45.6	35.6	41.2	47.1	44.8
	Model Chi-Squares				
Likelihood-Ratio Test Statistics	81.783	131.125	39.542	83.021	153.302
Score Test Statistics	82.582	107.972	32.578	81.274	152.087
Wald Test Statistics	81.896	86.023	31.272	79.089	150.467

Note: Data pertain exclusively to new (in 1992) firms (EINs) with positive payrolls in 1992.

Source: Special Tabulations of 1992-1996 BITS data matched with 1992 SMOBE and WOB data. This matched data series was created by Dr. Alicia Robb of the Federal Reserve Board of Governors while she was employed by the Office of Advocacy of the U.S. Small Business Administration.

MSA Status

The estimated hazard ratio associated with MSA locational status is only statistically significant for eating and drinking places owned by Asians and other minorities. Among these businesses, those located in MSAs have an estimated hazard of dissolution that is 73.7 percent that of businesses not located in MSAs. This particular finding is at odds with empirical results presented earlier in this report, as well as Robb (2000) and Boden (2000) where firms located in MSAs were found to have a higher hazard of dissolution, other things equal. Thus, the impact of MSA status on firms' hazard of dissolution may well vary by demographic category of ownership and more specific--e.g., 2-digit SIC--definitions of industry.

Census Region

In these models, the excluded, reference region is the North Central census region. Thus, the estimated hazard ratios for the regions specified in the models gauge the hazard of dissolution relative to this region. And these estimated ratios vary in terms of magnitude and statistical significance across the four demographic categories of ownership. The discussion of these estimates will be confined to those that are statistically significant (with a p-value of 0.05 or less).

White, non-Hispanic owned eating and drinking places' estimated hazards of dissolution are highest in the Northeast and South census regions, other things equal. By contrast, for Black owned eating and drinking places, the ceteris paribus hazards of dissolution are by far the lowest in these two census regions. For White, Hispanic owned businesses in this major industry group, the

estimated hazard of dissolution in the South census region is, other things equal, over twice that of the North Central census region. Finally, eating and drinking establishments owned by Asians and other minorities have an estimated hazard of dissolution in the South census region that's about 39 percent greater than their counterparts located in the North Central census region.

Gender

Other things equal, women owned eating and drinking places have notably higher estimated hazards of dissolution relative to businesses owned by men for both White, non-Hispanics and White Hispanics. However, the estimated hazard of dissolution of eating and drinking places owned by Black women is only about three-quarters that of eating and drinking places owned by Black men. (For Asians and other minorities, the estimated hazard ratio for gender is not statistically significant with a p-value of 0.05 or less.)

Demographic Composition by Census Division

As Table 3(a) indicates, every one-percent increase in a census division's population that is Black results in an *increase* in Black owned eating and drinking places' estimated hazard of dissolution of nearly 12 percent in those corresponding census divisions, other things equal. By contrast, every one-percent increase in a census division's population that is comprised of Asians and other minorities results in a four-percent *decrease* in Asian and other minority owned businesses' hazard of dissolution in corresponding census divisions, other things equal. (For White, non-Hispanic owned businesses, the estimated hazard ratio for the "population percent" covariate is statistically significant, but of negligible magnitude. And for White, Hispanic owned businesses,

the estimated hazard ratio for this covariate is not statistically significant.)

C. Estimation Results for Business Services (SIC 73)

As reported in Table 3(b), the proportion of business services firms that were started in 1992 and survived through 1996 equals 43.7 percent, overall, and 47.6 percent for White, non-Hispanic owned firms, 50.0 percent for White, Hispanic owned firms, 60 percent for firms owned by Asians and other minorities, and only 18.5 percent for Black owned firms. Below is a systematic evaluation of the estimates for the covariates in the proportional hazard models for business services firms.

Initial Firm Employment Size (1992 EIN Employment)

The estimated hazard ratios for initial firm employment size are statistically insignificant for White, non-Hispanic owned businesses and White, Hispanic owned businesses. For Black owned businesses, however, every one-employee increase in initial firm employment size results in a 7.4-percent decrease in their estimated hazard of dissolution, other things equal. And every employee increase in the initial employment size of businesses owned by Asians and other minorities results in an estimated 16.9-percent decrease in these businesses' hazard of dissolution, other things equal.

Incorporated Status

As has been the case throughout this study thus far, business services firms organized as S corporations are likewise at a substantially lesser hazard of dissolution than their unincorporated counterparts. This finding is statistically significant for each of the four demographic categories of ownership with a p-value of less than 0.05.

Table 3(b). Estimated Hazard Ratios for Firms (EINs) Started in 1992 in the Business Services Industry (SIC 73) by Race of Ownership

	Hazard Ratios				
Covariate Descriptions	**White, Non-Hispanic Owned**	**Black Owned**	**White, Hispanic Owned**	**Asian/Other Owned**	**All Races**
1992 EIN employment	1.000	0.926*	1.000	0.831*	1.000
Incorporated EIN	0.633*	0.374*	0.647**	0.414*	0.610*
dummy: MSA	1.409*	1.915**	1.080	3.681*	1.483*
dummy: northeast census region	1.437*	0.990	0.239*	0.978	1.088
dummy: south census region	1.731*	1.703**	0.835	1.050	1.252*
dummy: west census region	1.440**	0.987	0.746	0.686	0.986
dummy: woman-owned EIN	0.693*	1.533*	1.167	0.714	0.848*
92 percent of pop. total by race and creg.	1.016*	0.930*	0.959*	1.029	0.996
dummy: black-owned EIN					1.084
dummy: hispanic-owned EIN					0.694
dummy: asian/other-owned EIN					0.543**
* underlying coefficient is significant with a "p-value" of ≤ 1 percent; ** underlying coefficient is significant with a "p-value" of ≤ 5 percent					
Number of Observations	1,835	543	253	313	2,944
Percent of EINs Surviving to 1996	47.6	18.5	49.0	59.9	43.7
	Model Chi-Squares				
Likelihood-Ratio Statistics	102.020	91.179	22.575	41.579	235.126
Score Test Statistics	100.577	84.202	22.027	32.609	238.509
Wald Test Statistics	98.833	82.879	20.840	34.909	229.996

Note: Data pertain exclusively to new (in 1992) firms (EINS) with positive payrolls in 1992.

Source: Special Tabulations of 1992-1996 BITS data matched with 1992 SMOBE and WOB data. This matched data series was created by Dr. Alicia Robb of the Federal Reserve Board of Governors while she was employed by the Office of Advocacy of the U.S. Small Business Administration.

MSA Status

One may expect business services firms to thrive in MSAs. However, the estimated hazard ratios for the MSA dummy covariate suggest otherwise for each of the four demographic categories of ownership. While the estimated hazard ratio for this covariate is statistically insignificant for businesses owned by White, Hispanic owned businesses, the corresponding estimates for businesses in the other three ownership categories are statistically significant (with a p-value of 0.05 or less) and indicate notably higher hazards for dissolution.

Curiously, the estimated hazard ratio for MSA status shows that businesses owned by Asians and other minorities that are located in MSAs are at almost four times the hazard of dissolution relative to their counterparts located in non-MSAs, other things equal. Of course, even within this major industry group, there is considerable diversity in more specific type of business. Analyses at the 3- or 4-digit SIC level would be desirable, but, unfortunately, the sparsity of data in the matched SMOBE-WOB-BITS data makes this impossible.

Census Region

For business services, the estimated hazard ratios for specified dummy covariates corresponding to three of the four census regions vary by demographic category of ownership. For White, non-Hispanic owned businesses the estimates indicate ceteris higher hazards of dissolution--on the order of some 44 to 73 percent--in the Northeast, South, and West census regions compared to the North Central census region. For Black owned businesses, the only statistically significant estimated hazard ratio associated with census region is that of the South census region, where Black

owned businesses are at an estimated hazard of dissolution that is about 70 percent greater than that of Black owned businesses in the North Central census region, other things equal. For White, Hispanic owned businesses, the estimated hazard ratio for the Northeast census region covariate is the only statistically significant estimate associated with census region. According to this estimate, White, Hispanic owned businesses have an estimated, ceteris paribus hazard of dissolution that is just 24 percent the hazard of dissolution of corresponding businesses located in the North Central census region. None of the three estimated hazard ratios for the census region dummy covariates is statistically significant for businesses owned by Asians and other minorities.

Gender

According to Table 3(b), business services firms owned by White, non-Hispanic women have an estimated hazard of dissolution that is about 69 percent the hazard of dissolution of business services firms owned by White, non-Hispanic men, other things equal. In contrast, business services firms owned by Black women have an estimated 53 percent higher hazard of dissolution than corresponding firms owned by Black men, other things equal. For the other two demographic categories of ownership, the estimated, ceteris paribus hazards of dissolution corresponding to gender are not statistically significant.

Demographic Composition by Census Division

According to Table 3(b), the estimated hazard ratios associated with the "population percent" covariate are statistically significant (with a p-value of less than 0.01) for three of the four demographic categories of ownership, although they vary in magnitude. For every one-percent

increase in a census division's population that is white, the estimated, ceteris paribus hazard of dissolution of White, non-Hispanic owned business services firms located in corresponding census divisions rises by 1.6 percent. However, every one-percent increase in a census division's population that is Black results in a 7-percent decrease in Black owned businesses' estimated, ceteris paribus hazard of dissolution. And, every one-percent increase in a census divisions population that is comprised of Asians and other minorities results in an estimated 4-percent decrease in the ceteris paribus hazard of dissolution among businesses owned by Asians and other minorities.

VI. Conclusions and Suggestions for Further Research

The BITS data have already proven to be a valuable resource for empirical analyses of business, establishment, and employment dynamics. See, for example, Boden (2000). The matched SMOBE-WOB-BITS data open up even more dimensions for prospective empirical analyses by augmenting the BITS with information on the racial/ethnic and gender classification of firms' ownership.

Indeed, in this study, the matched SMOBE-WOB-BITS data were used to calculated new business survival rates (between 1992 and 1996) by demographic category of business ownership, including survival rates for selected 2-digit SIC industries. Estimated, ceteris paribus estimates of the determinants of business dissolution were also adduced in this study by demographic category of ownership. Of course, the matched file can also be used to assess business employment change for various demographic classifications of business ownership, although this was not an area explored here.

One of the more interesting findings of this study concerns how differences in new business dissolution rates (and their determinants) across demographic categories of ownership vary by major industry group (2-digit SIC). We looked at two major industry groups--viz., eating and drinking places and business services. The findings for these two major industries should encourage similar examinations of other 2-digit SIC industries (to the extent that the volume of the matched data permits).

It will be important to match the 1997 SMOBE and WOB data to the 1997 panel of the BITS. One the more portentous assumptions made in this study was that businesses' demographic category of ownership in 1992 did not change in subsequent years. Obviously, this need not be the case, and adding 1997 data will help to shed light on this issue.

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Appendix A.

A description of hazard functions and the Cox (1972) proportional hazard methodology is as follows. Let T denote a random variable representing business survival duration, where t is a realization of T. The cumulative failure distribution is given by:

$$F(t) = P(T \le t) = \int_0^t f(s)ds$$

The complementary, cumulative business survival function is given by:

$$S(t) = 1 - F(t)$$

The business failure probability density function is given by:

$$f(t) = \frac{dF(t)}{dt} = -\frac{dS(t)}{dt}$$

The so-called hazard function is given by:

$$h(t) = \frac{f(t)}{S(t)} = -\frac{d \ln S(t)}{dt} \qquad (2a)$$

The hazard rate is the probability that a business will close in the next infinitesimally short interval t+Δ, given that it has survived until time t. That is:

$$h(t) = \lim_{\Delta \to 0} \frac{P(t \le T \le t + \Delta \mid T \ge t)}{\Delta}$$

The Cox proportional hazard model with covariates can be expressed as:

$$h(t) = h_0(t) e^{\sum_k b_k x_{ik}} \qquad (2b)$$

or

$$\ln h(t) = \ln h_0(t) + \sum_k b_k x_{ik} \qquad (2c)$$

where $h_0(t)$ is the baseline hazard rate or function, the x's are explanatory variables or covariates, and the b's are parameter estimates (obtained by maximization of a partial log-likelihood function). The Cox proportional hazard model is a semi-parametric model in that it allows for estimation of the b's without estimation of $h_0(t)$. The advantages of the Cox model is that its parameter estimates are easily interpreted and no restrictive assumptions about the underlying survival duration distribution (and, hence, baseline hazard function) are required

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