Are Immigrants Particularly Entrepreneurial? Firm Ownership as a Key Element in Immigrant Income Assimilation: On-line Appendices

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1 Appendix A: Other Plots and Data

This Appendix contains supplementary plots and tables mentioned in the text.

1.1 Plots with Tax Filer Base

In this section, we present plots of firm ownership rates using the number of T1 taxfilers as the base rather than the number of initial entrants in order to present the rates in a form that is more similar to other papers.

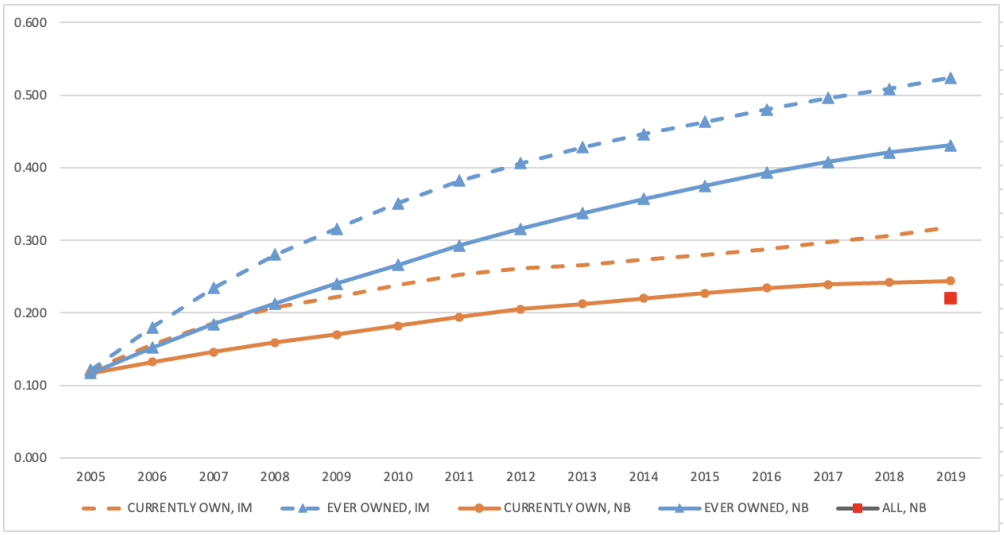


Figure 1: Proportion of Taxfilers Who Currently Own or Have Ever Owned a Firm By Year: 2004 Immigrant and Native Born Cohorts

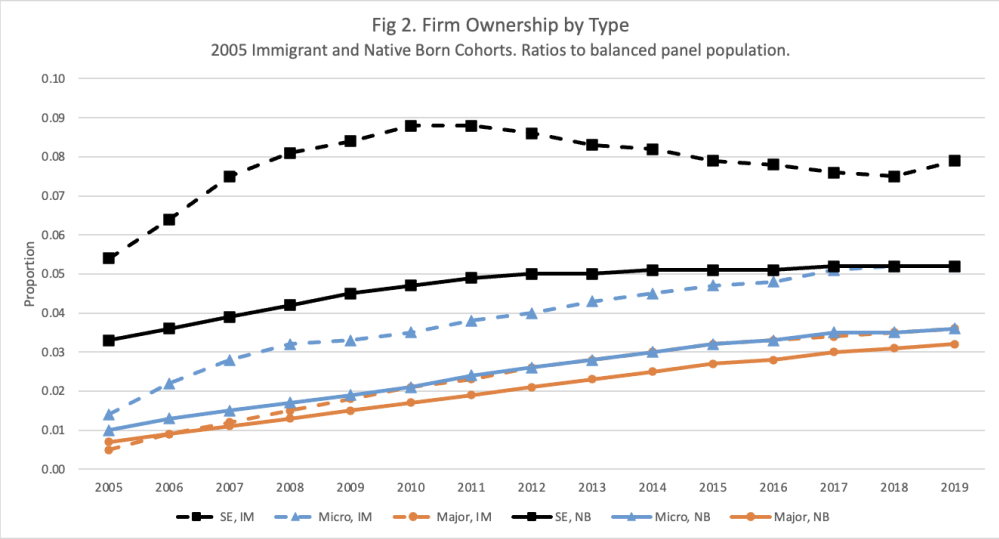


Figure 2: Firm Ownership by Type: 2004 Immigrant and Native Born Cohorts

1.2 Patterns for Other Entry Cohorts

In this section, we recreate Figures 1 and 2 from the text (which is for the 2005 entry cohort) for the 2010 and 2015 cohorts. The patterns are substantively the same: immigrants open more firms and the key difference in firm ownership is in SE and MICROINC firms.

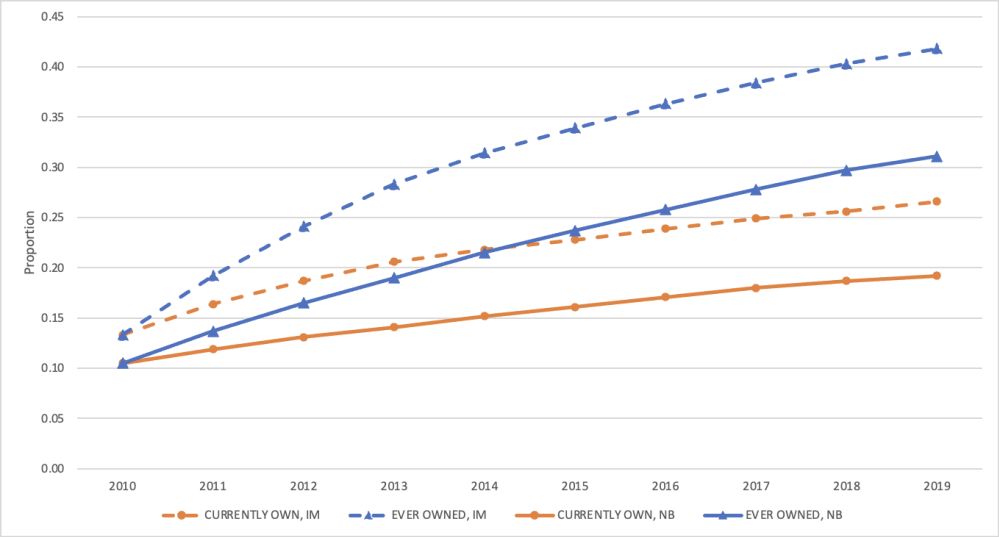


Figure 3: Proportion of People that Currently Own or Have Ever Owned a Firm of Any Kind, 2010 Immigrant and NB Cohorts

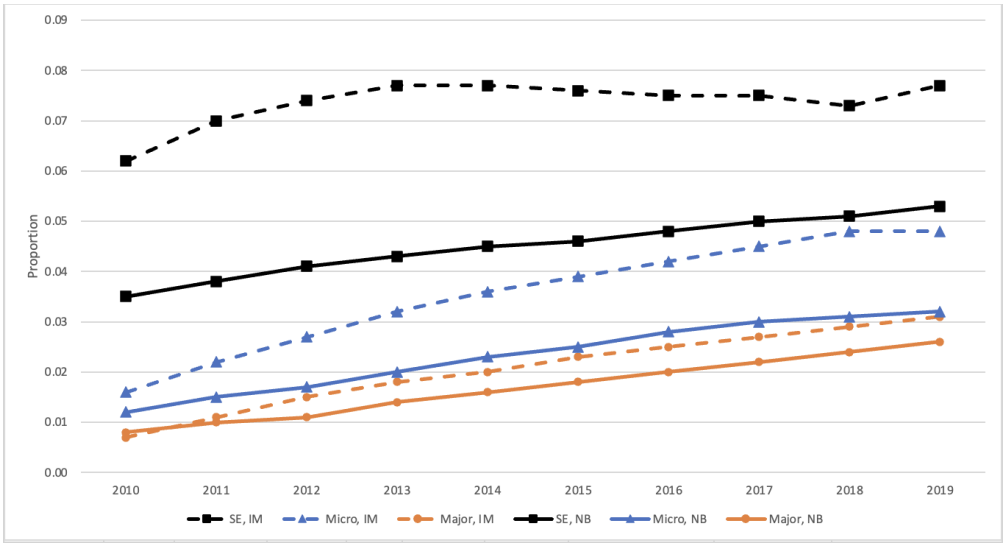


Figure 4: Firm Ownership by Type, 2010 Immigrant and NB Cohorts

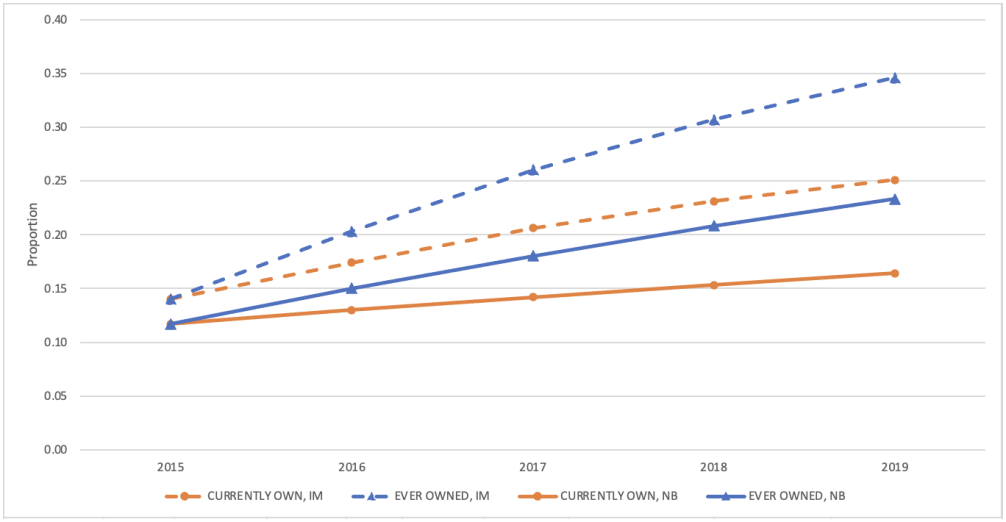


Figure 5: Proportion of People that Currently Own or Have Ever Owned a Firm of Any Kind, 2015 Immigrant and NB Cohorts

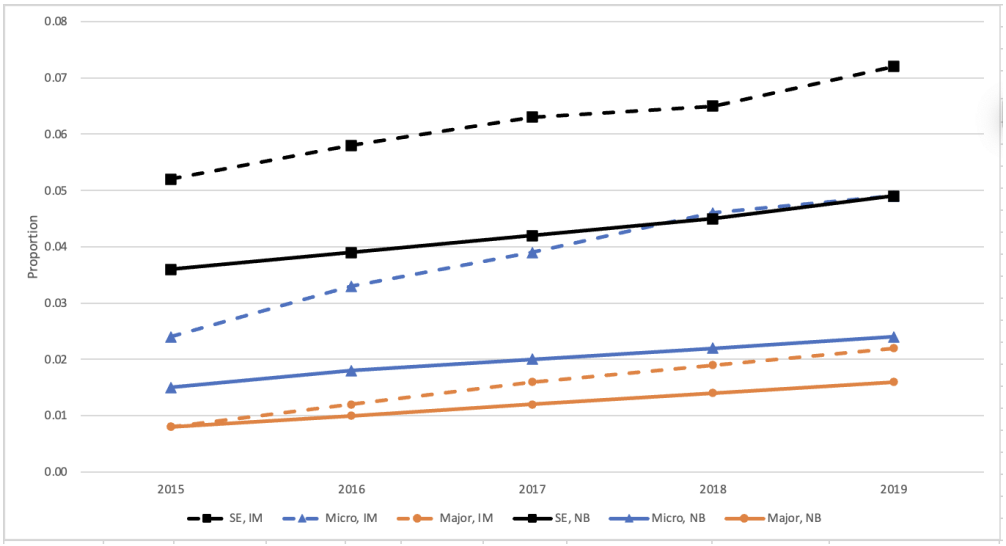


Figure 6: Firm Ownership by Type, 2015 Immigrant and NB Cohorts

1.3 Counterfactual Income Distributions

In this section, we construct a counterfactual income distribution for immigrants from the 2005 entry cohort at 15 years after arrival. In particular, given the large proportion of immigrants who become SE, we focus on the sum of self-employed and paid earnings, noting that the sum has a distribution given by, $p_E^j * F_E^j(y) + p_S E^j * F_S^j E(y)$, where F_E^j is the CDF for paid earnings for group j (j = I for immigrants or NB for native born), $F_S^j E$ is the CDF for self employed earnings, p_E^j is the proportion of group j who are paid employed, and $p_S E^j$ is the proportion who are self-employed. Since the non-employed are typically included in examinations of immigrant assimilation that exclude the self-employed, we count 0s as part of the E distribution. In the first counterfactual, we replace p_E^I and $p_S E^I$ with their native born counterparts. This will tell us whether the fact that immigrants are more involved in firm ownership explains much of the difference in patterns between immigrants and the native born. In the second counter-factual, we replace both the probabilities and $F_S^I E(y)$ with its NB counterpart. This will tell us what immigrant income would look like if they had their paid employment earnings but the self-employed earnings and probabilities of the native born. The resulting CDFs are plotted in the following figure.

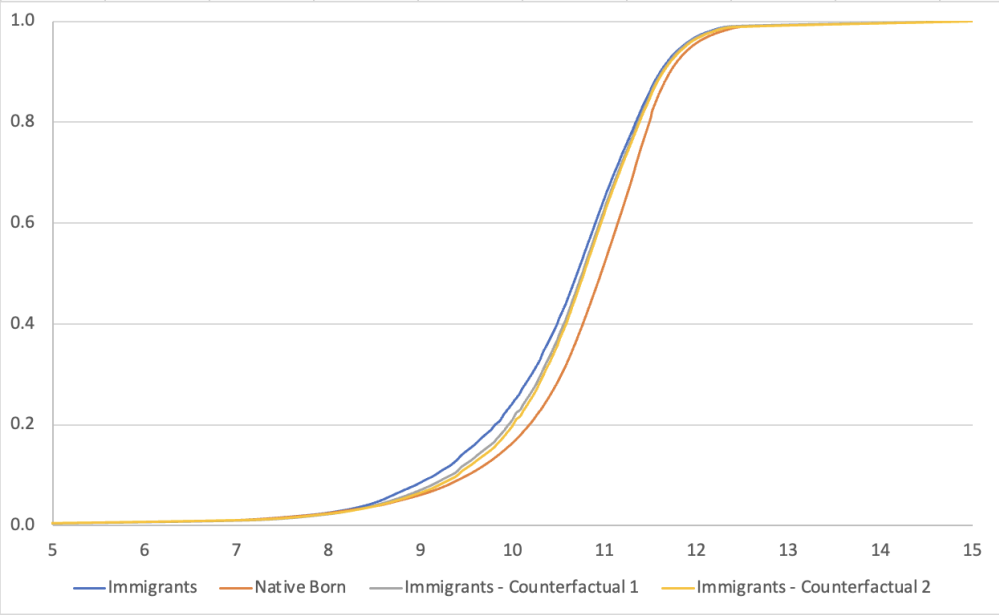


Figure 7: CDFs of Log Total Income: Counterfactuals and Actual

From the figure, we can see that the first counterfactual accounts for about 40% of the difference in the CDFs around the 20th percentile and is effectively no different from the actual immigrant CDF around the 80th percentile. Shifting immigrants to having the NB proportion SE essentially makes the differential between immigrants and the NB at the 20th percentile the same as the difference at the 20th percentile in paid employment earnings. Differences in income conditional on SE income has very little effect. The fact that SE earnings are concentrated toward the bottom of the total income distribution accounts for why the lower part of the distribution fares particularly badly for immigrants relative to the NB.

1.4 Firm Ownership by Entry Class

The higher firm ownership rates among immigrants potentially reflects the selection inherent in the immigrant entry system. The Canadian immigrant selection system in the years of entry for the immigrants we study (2005 to 2019) consisted of three broad classes. The least selected of these were the Refugee and Family Classes, both of which permitted entry on humanitarian grounds (i.e., without direct relation to the skills of the entrants). The third main class was the Economic Class, who were selected based on anticipated contributions to the economy.[1] The Economic Class was further subdivided into the Business Class (making

[1]Over our sample period, 54% of immigrants gaining Permanent Resident (PR) status were in the Economic Class, with 27% entering in the Family Class and 12% entering as Refugees.

up 8% of the Economic Class in 2013), entrants nominated by the provinces (the Provincial Nominees Program, making up 12% of the Economic Class) and the Federal Skilled Worker Class (making up 79%), in which applicants were assessed based on skills such as education and language ability under the point system.[2]

The Business Class consisted of three sub-classes: the Entrepreneur Class (who were required to establish or buy a business that contributes "to the Canadian economy and create one or more jobs in Canada in addition to the jobs created for the entrepreneur and his family"; the Investor Class (which required having a net worth of at least $800,000 and providing $400,000 to a provincial government for it to invest); and the Self-Employed Class (which was targeted at groups such as artists and professional athletes). (Citizenship and Immigration Canada web page from 2001 as quoted in **?**)

Beginning in 2014, the federal government replaced the Entrepreneur and Investor Classes with the Start-up Visa program. Under the new program, to be successful, an applicant must have secured the endorsement of an angel investor group, a venture capital company or a business incubator and show that they have sufficient funds to start the enterprise in Canada.[3] Because this involves showing that a company will actually be started, it seems likely that the rates of opening a business should be higher than what we document for the Federal Entrepreneur Class. But in 2019, only about 500 people entered through the Start-up Visa out of a total inflow of approximately 341,000, compared to approximately 11,000 business class entrants in the previous system.[4]

The selection of immigrants through the point system and assessments in the Business Classes represents a key difference between immigrants and the native born. This raises the question of whether the patterns shown so far reflect the imprint of the selection system. To answer this, in Figure 8, we present the proportion of each entry class who own a MAJINC firm in each year since arrival for the 2005 entry cohort. We restrict attention to the Principal Applicants - the people actually assessed in each class, rather than their accompanying family. For the Skilled Worker and Family Class, the proportions are very small in the first year after arrival (about 1%). In comparison, for entrants in the Entrepreneur Class - who were admitted on the promise of opening a firm - about 10% own an incorporated firm in their

[2]The province of Quebec runs a somewhat separate immigration assessment system. Immigrant applicants to Quebec go through a two stage process, clearing an assessment by Quebec first and then the federal government. The entry classes essentially line up with the federal classes and the numbers admitted are part of the overall federal admission limits.

[3]More details on the eligibility requirements for a Start-up Visa can be found at `http://www.cic.gc.ca/english/helpcentre/answer.asp?qnum=645&top=6`

[4]The Start-up Visa entrants are for Canada excluding Quebec. Quebec maintained the old system with Entrepreneur, Investor, and Self-employment Classes. Source: `https://www.cic.gc.ca/opendata-donneesouvertes/data/EN_ODP-PR-ProvImmCat.xlsx`

first year in Canada. Interestingly, the latter percentage only rises in their next two years in Canada before declining thereafter. Entrants in the other classes, instead, show an increase in their firm ownership rates and by year 15 the Skilled Worker entrant rates have reached about 50% of those for the Entrepreneur Class and are on a rising trend. The other business classes - Investor and Self-Employed - fit in between but also with a rising trend. By 15 years after arrival, 34% of Entrepreneur Class principal applicant immigrants have been in the MAJINC state at some point compared to 12% of the Skilled Class entrants.[5] That is, only about a third of immigrants admitted under the requirement that they open or buy a firm have actually done so by 15 years after arrival. Given this, the vast majority of immigrant firm owners are no more selected for entrepreneurship than NB entrants and, so, we would not expect their firms to perform better because of greater selectivity.

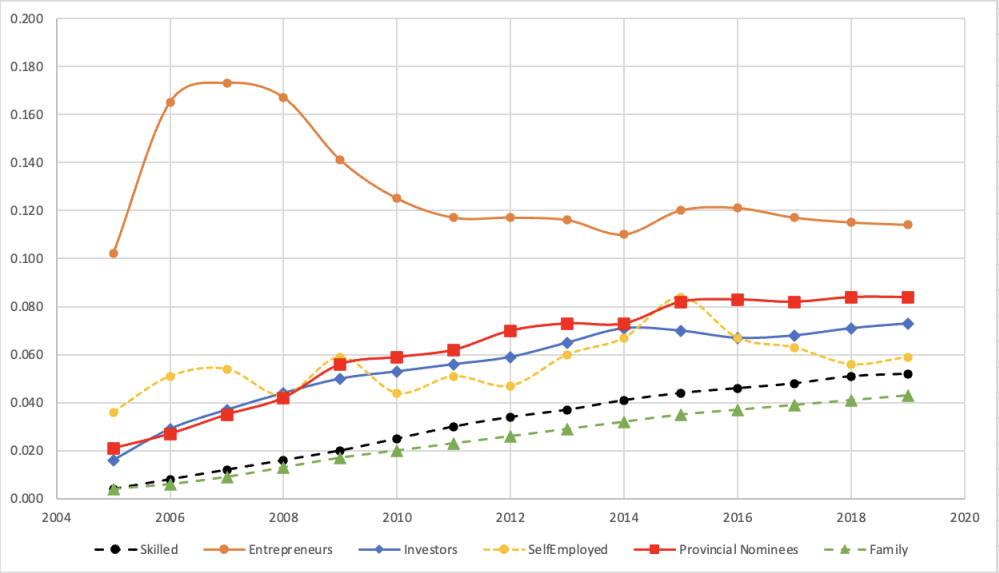


Figure 8: Proportion of Tax Filers Who Own a MAJINC Firm by Immigration Entry Class: 2005 Cohort

These patterns combined with the fact that the Skilled Worker and Family Classes are much larger than the Entrepreneur class mean that while 15% of immigrant owned MAJINC firms are owned by entrants in the Entrepreneur Class in the first year after arrival, by 15 years after arrival that percentage has fallen to under 2% and the Skilled Worker Entrants' percentage is 56%. Of the immigrants who are ever in the MAJINC state in the first 15 years after arrival, 38% entered in the Skilled Worker Class and 21% entered in the Family Class, compared to only 5% who entered in the Entrepreneur Class. The implication is that

[5]If we add MICROINC firms then the percentage of Entrepreneur class entrants who own an incorporated firm rises to 21%. For Skilled class entrants the comparable number is 13%.

outcomes for the classes other than the Entrepreneur Class, and the policies that affect them, are ultimately more important for firm ownership patterns than those for the Entrepreneur Class. At the same time, while Entrepreneur Class entrants make up a small proportion of firm owners it is approximately double the proportion of immigrants who enter in that class in our data (0.9%).[6] This suggests some success in selecting people who open firms (even if not to the degree that they are seemingly legally required to) but as we will see in section 4, the firms they are opening are not particularly productive.

1.5 Cluster Specific Paths for the Native Born

In this section, we present the equivalent of Figure 4 in the text for the native born. We present the native born plots in an appendix to save on space in the main text and because the patterns are substantively similar to those for immigrants.

[6]By way of comparison, Skilled Class entrants made up 49% of entrants and, by 2019, 56% of MAJINC firm owners.

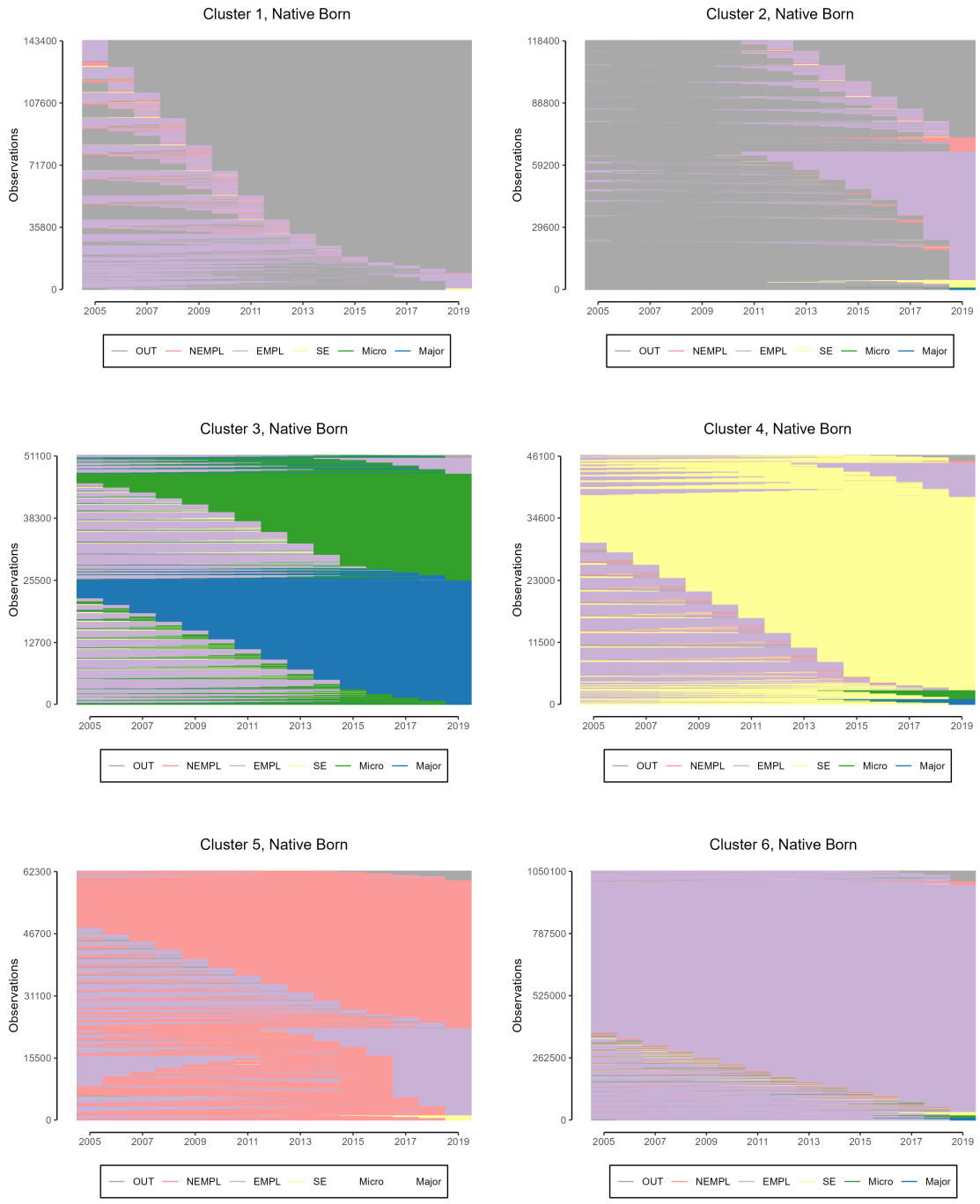


Figure 9: Paths Across States with Time Since Entry by Cluster: Native Born

1.6 Transition Matrices at Various Years

In this appendix, we present transition matrices between year 1 and year 2 after arrival, year 10 and year 11 after arrival, and year 14 and year 15 after arrival for both the immigrant

and native born cohorts. Note that some entries are missing in the first immigrant matrix because confidentiality issues related to small numbers.

2005			**Immigrants**			
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.482	0.176	0.281	0.047	0.011	0.003
NEMPL	0.058	0.590	0.294	0.046	0.008	0.003
EMPL	0.036	0.111	0.815	0.026	0.011	0.002
SE	0.046	0.066	0.207	0.637	0.036	0.008
Micro	0.036		0.055		0.703	0.169
Major	0.032		0.036		0.147	0.765

2005			**Native Born**			
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.740	0.029	0.211	0.015	0.004	0.002
NEMPL	0.088	0.581	0.298	0.029	0.003	0.001
EMPL	0.062	0.037	0.882	0.013	0.004	0.001
SE	0.081	0.036	0.183	0.672	0.021	0.007
Micro	0.057	0.007	0.077	0.011	0.717	0.132
Major	0.036	0.003	0.042	0.004	0.083	0.833

2014		**Immigrants**				
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.899	0.023	0.057	0.014	0.006	0.002
NEMPL	0.071	0.742	0.136	0.041	0.007	0.002
EMPL	0.030	0.057	0.883	0.017	0.010	0.003
SE	0.049	0.067	0.106	0.749	0.024	0.005
Micro	0.032	0.021	0.066	0.017	0.762	0.103
Major	0.015	0.008	0.025	0.004	0.111	0.837

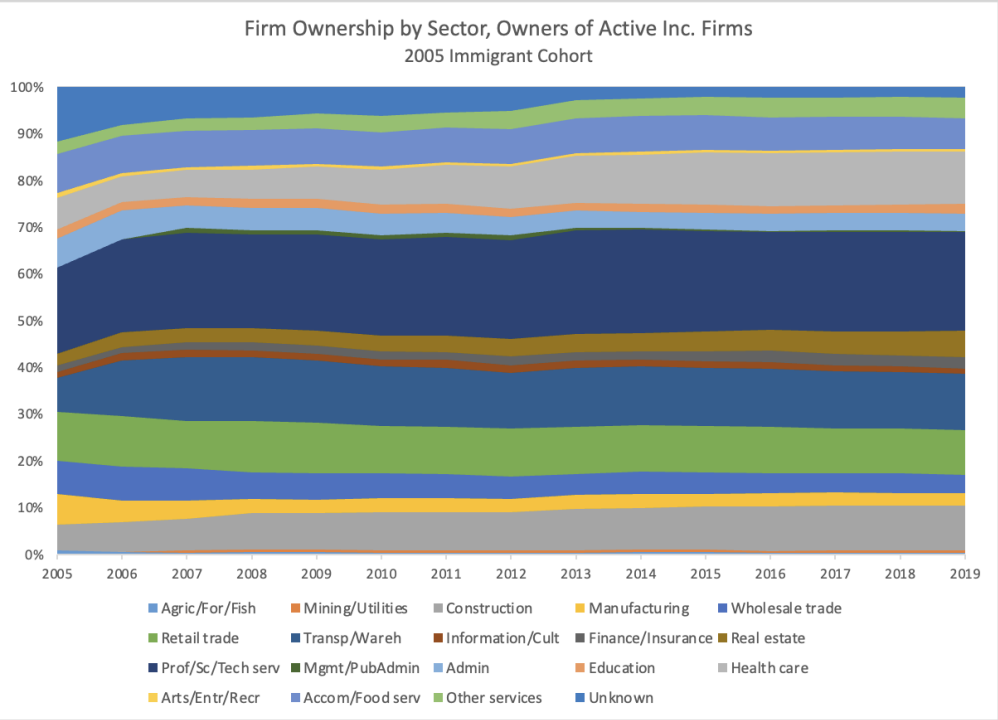
2014		**Native Born**				
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.899	0.023	0.057	0.014	0.006	0.002
NEMPL	0.071	0.742	0.136	0.041	0.007	0.002
EMPL	0.030	0.057	0.883	0.017	0.010	0.003
SE	0.049	0.067	0.106	0.749	0.024	0.005
Micro	0.032	0.021	0.066	0.017	0.762	0.103
Major	0.015	0.008	0.025	0.004	0.111	0.837

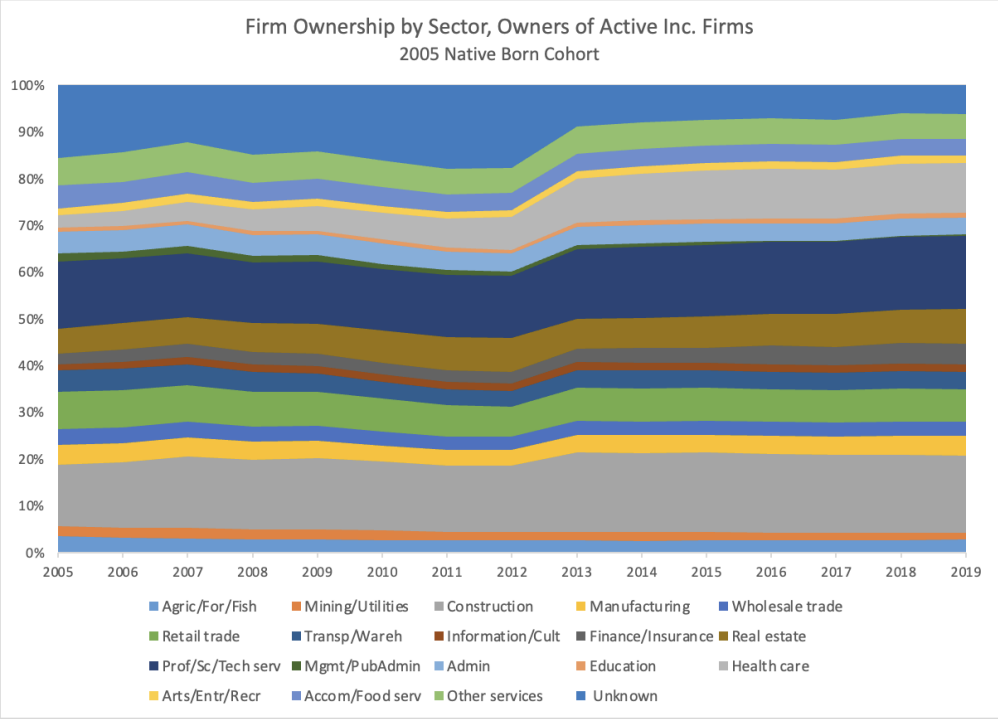
2018		**Immigrants**				
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.916	0.017	0.046	0.014	0.005	0.002
NEMPL	0.087	0.730	0.116	0.058	0.007	0.002
EMPL	0.028	0.030	0.911	0.019	0.009	0.002
SE	0.046	0.040	0.101	0.788	0.022	0.004
Micro	0.036	0.014	0.065	0.019	0.784	0.082
Major	0.022	0.005	0.027	0.003	0.100	0.842

2018		**Native Born**				
State at	year t+1					
year t	OUT	NEMPL	EMPL	SE	Micro	Major
OUT	0.760	0.036	0.174	0.020	0.006	0.003
NEMPL	0.101	0.674	0.186	0.034	0.004	0.001
EMPL	0.049	0.017	0.917	0.010	0.005	0.002
SE	0.074	0.024	0.115	0.765	0.018	0.005
Micro	0.047	0.007	0.062	0.011	0.793	0.080
Major	0.032	0.002	0.024	0.003	0.073	0.866

1.7 Industrial Composition

In this section, we present plots of the industrial distribution of incorporated firms for the 2005 immigrant and native born entry cohorts across various years as well as results from a counterfactual exercise in which we ask what Immigrant incorporated firm Revenues and Value Added Per Worker would look like if they had the NB firms' industrial composition





In the following figures, we present mean Revenues and Value Added per Worker for Immigrant and NB firms in the 2005 entry cohort. As in the analyses of the distributions of these outcomes presented in the text, the NB firms are superior in both dimensions. We

also present, in each case, counterfactuals in which we use the mean of the outcome in each 2 digit industry in each year for Immigrant firms and combine them with the proportions of NB firms in each industry to form an overall mean that represents what the Immigrant firm outcomes would look like if they had the NB firm industrial distribution. In both cases, the counterfactual results are very similar to the actual Immigrant firm mean outcomes, implying that differences in industrial composition do not explain the inferior Immigrant firm performance.

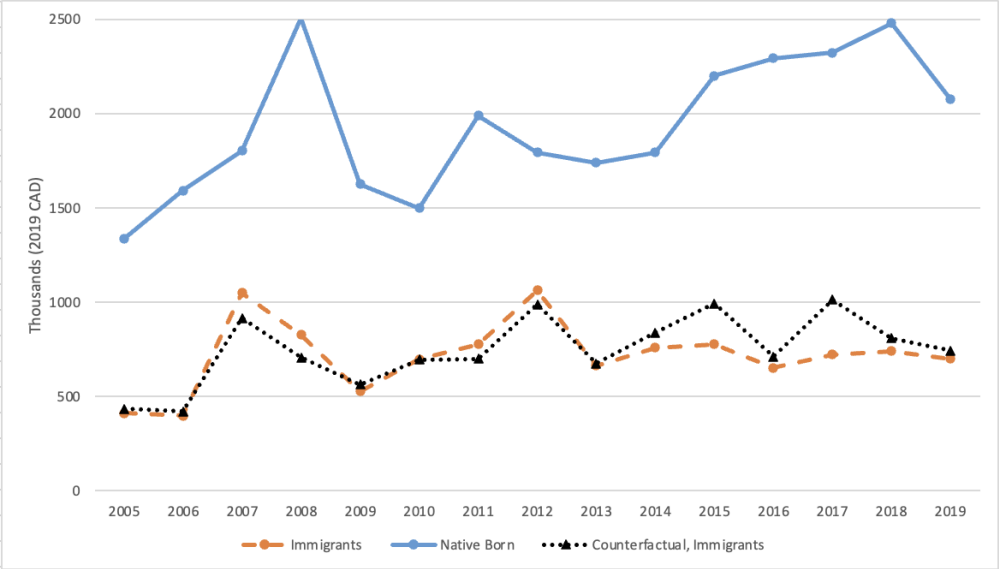


Figure 10: Mean Revenues for Active Inc. Firms: 2005 Immigrant and Native Born Cohorts and Counterfactual

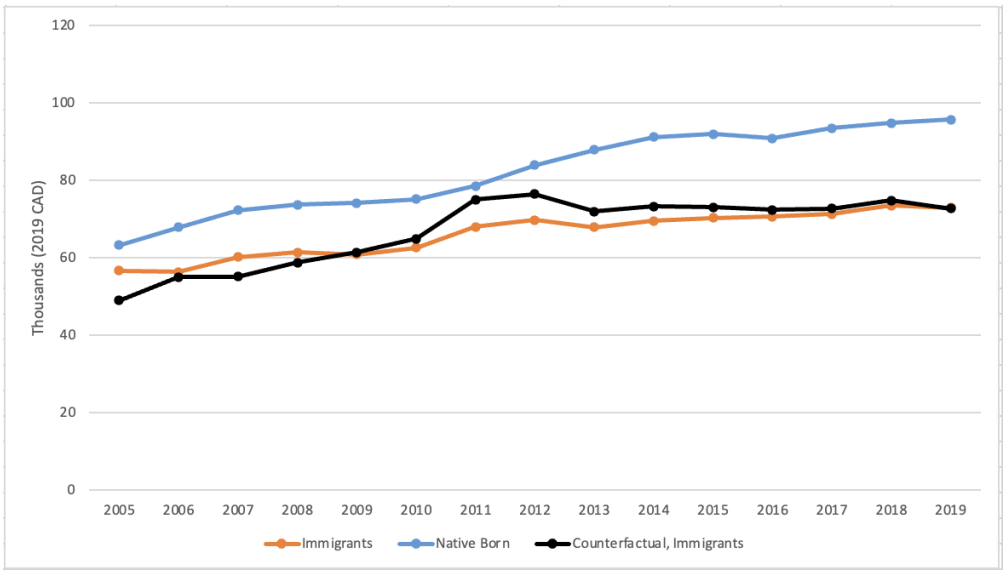
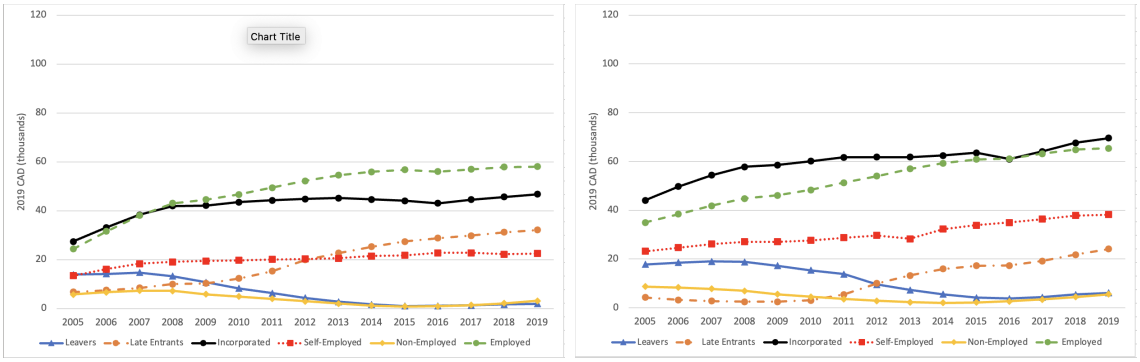


Figure 11: Mean Value Added Per Worker for Active Inc. Firms: 2005 Immigrant and Native Born Cohorts and Counterfactual

1.8 Earned Income Paths

In this section, we present plots of the mean earned income (paid plus self-employed earnings) versions of the income by cluster figure in section 3.2 in the paper. The figure in the text of the paper uses market income, which adds in income from all other sources than transfers. Importantly, this includes income from dividends and rents.



(a) Immigrants (b) Native Born

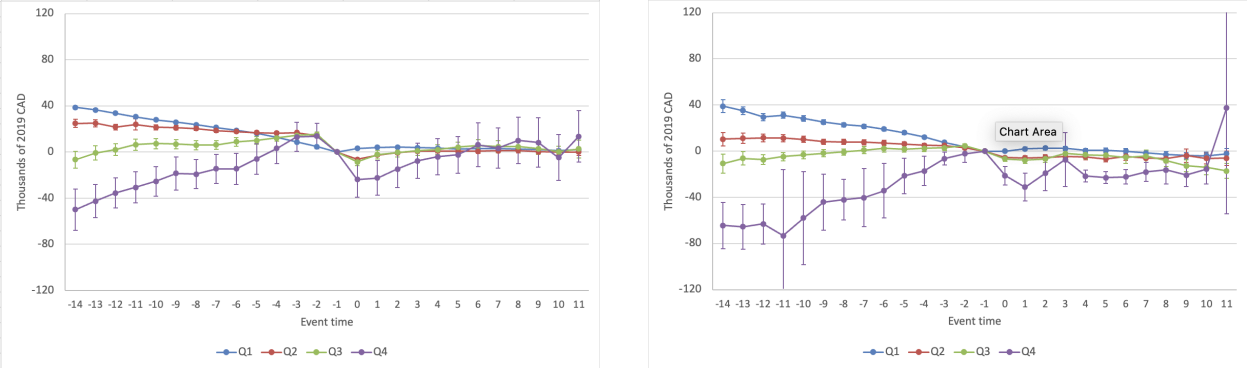
Figure 12: Mean Earned Income by Cluster, 2005 Cohort

Mean earned income in each year, including zeros.

1.9 Income Paths by Quartile, Immigrants and Native Born

1.10 Income Paths by Income Quartile

A key finding in **?** is that higher earned income workers are more likely to open incorporated firms but that entrepreneurs enjoy similar income benefits to firm opening regardless of where in the earned income distribution they started. In Figure 16, we replicate their exercise for firm ownership entry for SE and INC entry of immigrants by quartile. We form the quartile cut-offs using the pooled data for the always EMPL/NEMPL comparison group for the SE entrants and for the always EMPL comparison group for the INC entrants. We assign firm owners to a quartile based on the mean of their market income in the three years prior to firm opening. The plotted lines correspond to the β coefficients in our event study specification run separately by quartile, firm ownership type and immigrant status, where we use non-owners from the whole distribution in order to provide a common comparison for all the owner groups.



(a) SE Entry

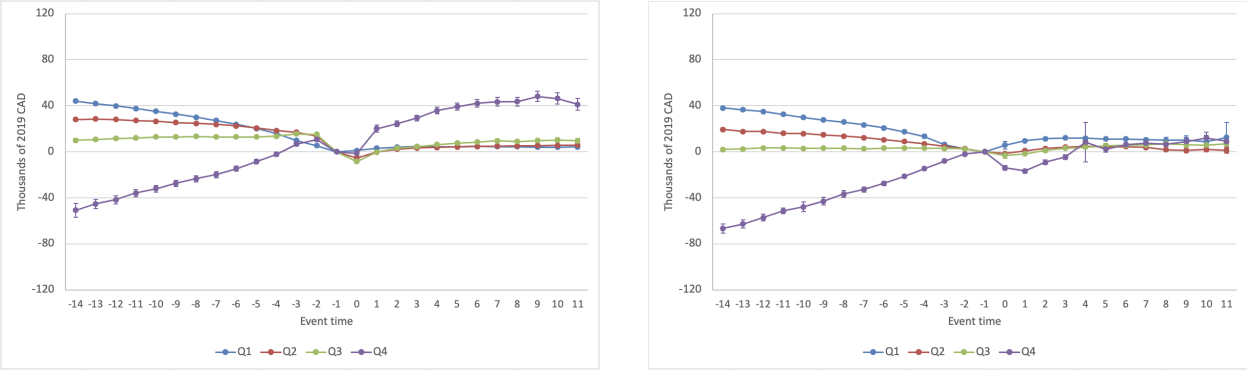
(b) INC Entry

Figure 13: Market Income Paths Around Firm Ownership Entry by Quartile of Prior Market Income, Immigrants

2005 Immigrant Cohort. Quartiles of Average Market Income in t*-1, t*-2, and t*-3. Income Quartile cut-offs based on always-EMPL/NEMPL Native Born market income distribution for SE and for always-EMPL Native Born market income distribution for INC.

Both SE and INC entry show similar patterns with people in the lowest quartile experiencing declining market income and those in the top quartile having an increasing trend as they approach firm ownership. The second and third quartile entrants income paths lie between the two. In all cases, though, market income growth after entering firm ownership is no better than and in several cases, worse than that for the people who do not open firms. We present the same figures for the native born cohort below. The pre-ownership patterns

for the native born are quite similar to those for the immigrants but the native born fare somewhat better relative to non firm owners after ownership. What differs across the different firm type/immigration status groups is the proportion in each of the income quartiles. For immigrants who enter SE ownership, 71% were in the bottom income quartile in the three years before opening a firm and only 5% were in the top quartile. For immigrants who enter INC status, in contrast, 29% were in the bottom quartile and 33% were in the top. For the native born cohort, the numbers are 53% bottom quartile and 11% top for SE entrants, and 16% bottom and 43% top for INC entrants. We constructed counterfactual income paths for immigrants using their actual paths by quartile with the native born shares in each quartile to see if the native born advantage in income prior to firm ownership could explain post-ownership differentials. We find very little effect on the post-ownership income paths, perhaps because virtually no group does particularly well after ownership. This is in strong contrast to the results in **?** for Finland, where all quantile groups show substantial extra income growth after firm opening.



(a) SE Entry

(b) INC Entry

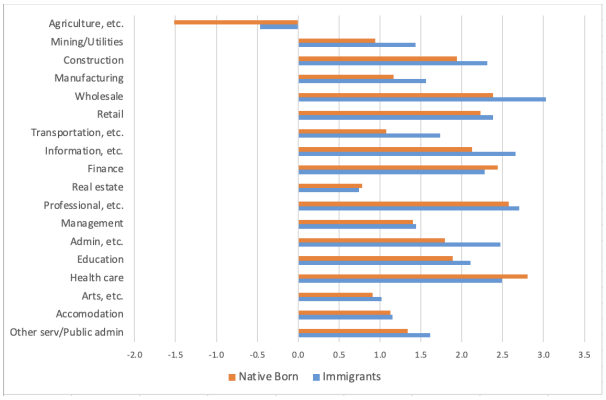
Figure 14: Market Income Paths Around Firm Ownership Entry by Quartile of Prior Market Income, Native Born

2005 Native Born Cohort. Quartiles of Average Market Income in t*-1, t*-2, and t*-3. Income Quartile cut-offs based on always-EMPL/NEMPL Native Born market income distribution for SE and for always-EMPL Native Born market income distribution for INC.

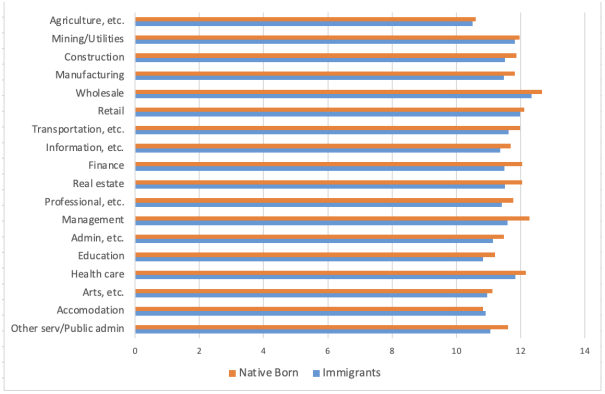
1.11 ARPK and ARPL Figures

In this section, we present plots of the average revenue product of capital (ARPK) and the average revenue product of labour (ARPL) for immigrant and non-immigrant firms by industry. We plot both means and standard deviations by industry. ARPK is calculated as total revenues divided by the total tangible assets of a firm for firms owned by entrants from

all cohorts. ARPL is calculated as total revenues divided by total employment of the firm for firms owned by entrants from all cohorts.

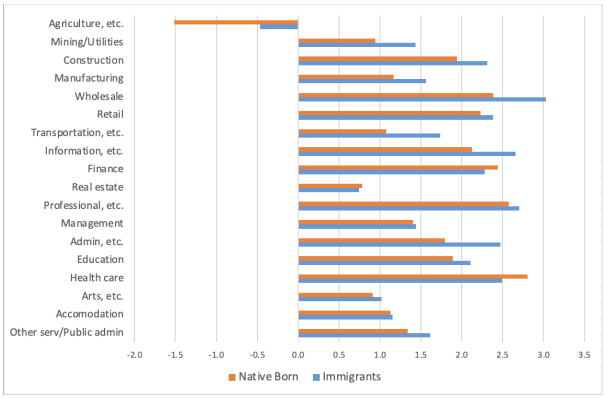


(a) ARPK

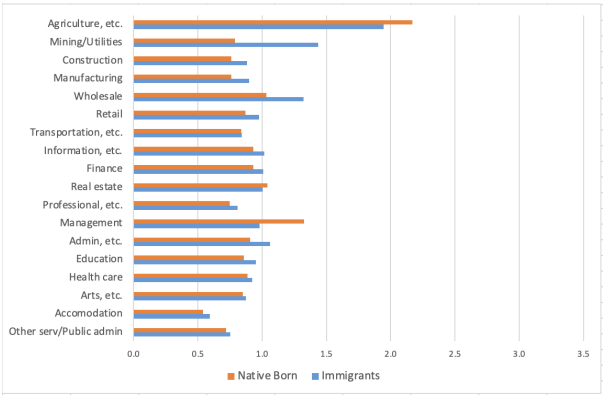


(b) ARPL

Figure 15: Means of ARPK and ARPL by Industry for Immigrant and NB Owned Incorporated Firms



(a) ARPK



(b) ARPL

Figure 16: Standard Deviations of ARPK and ARPL by Industry for Immigrant and NB Owned Incorporated Firms

2 B: Competing Risks Estimates

In this appendix, we investigate the employment and earnings characteristics of paths into firm ownership for immigrants using a flexible competing risks framework. In particular, we assume that individuals can occupy one of four states in a period: MAJINC; MICROINC; SE; or a non-firm ownership state that combines the EMPL, NEMPL and OUT and which we will label ENO. We combine employment and non-employment because we want to focus

on the movements into firm ownership and include the OUT state to allow for the possibility that people moving through this state are just in another not working/non-firm-ownership state. As we will see, our specification allows for different movements into firm ownership from the NEMPL/OUT and EMPL states.

In our competing risks framework, we estimate the time until first movement out of the ENO state into each of the other three possible states, using an assumption that all immigrants start in the ENO state just after arrival. Thus, for each of the other possible states, there is a latent time, $T_{ENO,m}$, at which the person would transit to state m if that were the only other possible destination. Associated with each of these latent times is a hazard rate, $h_{ENO,m}(\tau)$, where τ is time, so far, in the ENO state. We assume that the three processes associated with the three exit routes from ENO are independent and that the probability of a tie in time of exit is zero. Then the person is observed to exit to the state with the shortest associated time to exit so that the time spent in the ENO state is given by, $T_{ENO} = min(T_{ENO,MAJINC}, T_{ENO,MICROINC}, T_{ENO,SE})$.

We can estimate this model by estimating the hazard rates, e.g., the probability a person who is currently ENO moves into the MAJINC state in the next period. This can be estimated as a simple probit-type specification with the set of people included in the estimation (the risk set) including all those who have not so far exited the ENO state. Once a person exits to a particular firm ownership state, the preceding ENO spell is treated as a censored observation on the processes determining exit to the other ownership states. We assume that our covariates have the same effect on exits in all years after arrival.

We estimate the model pooling together our 2005 through 2016 entry cohorts and include a complete set of entry cohort, origin, and current location fixed effects. The only other covariates are the elements of a set of variables that take advantage of our rich tax data to capture the relationship between the earnings and employment paths followed by immigrants and their tendency to open firms. In particular, we calculate the earnings quintiles for all workers (immigrant and non-immigrant pooled) for each year and then assign workers to a 6 by 6 grid defined by those quintiles and a state of not working (i.e., being in either NEMPL or OUT). We include a complete set of 35 dummies corresponding to all but one of the cells in a grid defined by the combination of the states occupied in the previous two years, thereby capturing any earnings path in those two years.

Table 1 contains the estimated partial derivative effects for these dummy variables for the process defined by moving into the SE state. The estimated coefficients show a pattern with the coefficients moving from generally positive in the first row (representing people who were employed in year t-2 but not in t-1) to more negative as we move down each column. That

is, the more successful a person was in terms of earned income, particularly in the previous year, the less likely they were to open a SE firm. People in the top of the distribution in both years were 2% less likely to open an SE firm than a person who was in the top quintile in year t-2 but didn't work in t-1. People who moved up into the top two quintiles in t-1 or managed to stay in that part of the distribution were less likely to open an SE firm virtually regardless of their earnings in t-2.

Table 1: Entry into SE Process: Effects of Earnings Path for Previous 2 Years

		t-2						
		Q0	Q1	Q2	Q3	Q4	Q5	
t-1	Q0	0.000	0.013***	0.018***	0.020***	0.008	-0.008	Q0
		(.)	(0.001)	(0.002)	(0.003)	(0.005)	(0.007)	
	Q1	-0.025***	-0.017***	-0.011***	-0.007**	0.001	-0.006	
		(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.010)	
	Q2	-0.048***	-0.048***	-0.051***	-0.033***	-0.014***	-0.0126***	
		(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.005)	
	Q3	-0.064***	-0.069***	-0.070***	-0.071***	-0.052***	-0.034***	
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	
	Q4	-0.071***	-0.072***	-0.072***	-0.075***	-0.076***	-0.060***	
		(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
	Q5	-0.070***	-0.075***	-0.076***	-0.076***	-0.078***	-0.078***	
		(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	

corresponds to non-employment. Q1, ... Q5 correspond to earnings quintile groups. The numbers are marginal effects of being in a given category relative to the base of being non-employed in both of the previous two years. ***, **, and * correspond to statistical significance a the 1%, 5% and 10% levels.

We next present the estimated income quintile effects for the MAJINC process.

The MAJORINC results do not reveal a single, consistent pattern. The strongest positive effects (indicating more rapid movement into owning a MAJORINC firm) are for people in the top quintile in t-2 or who moved into that quintile in t-1. This may fit with results in Levine and Rubinstein (2017) showing that people who open incorporated firms were highly paid as employees, and with results in Gendron-Carrier (2018) that experience in high paying firms has a positive effect on incorporated firm ownership.

2.1 Partial Derivatives and Standard Errors

In equation 15.47 in Wooldridge (2005), Wooldridge proposes getting the partial derivatives of a probit in which there is an endogenous variable addressed using as a control function approach as the average across individuals. That is, following his notation, write the index

Table 2: Entry into MAJINC Process: Effects of Earnings Path for Previous 2 Years

		t-2					
		Q0	Q1	Q2	Q3	Q4	Q5
	Q0	0.000	0.000	0.002***	0.007***	0.010**	0.006*
		(.)	(0.000)	(0.001)	(0.001)	(0.002)	(0.003)
	Q1	0.001**	0.001*	0.001*	0.004***	0.003*	0.011*
		(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.005)
	Q2	0.002***	0.001***	0.002***	0.003***	0.007***	0.006**
t-1		(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
	Q3	0.002**	0.001*	0.000	0.000	0.003***	0.011***
		(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.002)
	Q4	0.002	0.003	0.000	0.000	-0.000*	0.006***
		(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
	Q5	0.004	0.006*	0.007***	0.003***	0.001***	0.002***
		(0.002)	(0.003)	(0.002)	(0.001)	(0.000)	(0.000)

Q0 corresponds to non-employment. Q1, ... Q5 correspond to earnings quintile groups. The numbers are marginal effects of being in a given category relative to the base of being non-employed in both of the previous two years. ***, **, and * correspond to statistical significance a the 1%, 5% and 10% levels.

function determining whether the dummy dependent variable takes a value of 1 as,

$$y_1^* = z_1\delta_1 + \alpha_2 y_2 + \theta\nu_2 + e_1 \tag{1}$$

where y_1^* is the index underlying the probit, z_1 is a set of exogenous variables that directly determine y_1^* , y_2 is the right hand side endogenous variable, ν_2 are the residuals from the first stage regression of y_2 on the set of instruments, and e_1 is an error term. We are assuming joint normality so that e_1 is normally distributed. We estimate a probit based on this and obtain estimates of δ_1, α_2, and θ. Then, we can form derivatives of the probability with respect to z_1 as,

$$\frac{1}{N}\sum_i \phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i})\hat{\delta} \tag{2}$$

where, $\phi(.)$ is the standard normal density. That is, we get the derivative for each observation and average across all individuals. We do the same for the derivative with respect to y_2.

To get the standard errors for these, we just need to use the Delta method. First, create the variance-covariance matrix for the partial effects for person i, which I will call V_i.

$$V_i = \frac{\partial\phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i})\hat{\delta}}{\partial\delta'} V_{\hat{\delta}} \frac{\partial\phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i})\hat{\delta}}{\partial\delta} \tag{3}$$

To construct this, note that,

$$\frac{\partial \phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i})\hat{\delta}}{\partial \delta'} = \phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i}) \cdot (-x\beta)\hat{\delta}x' + I_k \phi(z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i}) \quad (4)$$

where, $x\beta = z_{1i}\hat{\delta}_1 + \hat{\alpha}_2 y_{2i} + \hat{\theta}\nu_{2i}$ and I_k is the kxk identity matrix and k is the number of elements in the δ vector.

Then, if we assume that all observations are independent, the overall variance-covariance matrix is,

$$V = \frac{1}{N^2} \sum_i V_i \quad (5)$$

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